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[Document's Name] Patent Application

[Reference Number] 98-00231

[Submitting Date] January 30, 1998

[Destination] To the Commissioner of the J.P.O.

[Int. Cl] H04N 7/24

[Title of the Invention] IMAGE ENCODER AND IMAGE DECODER

[Number of the Invention] 13

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[Claim of priority based on Previous Application]

[Application No.] Application No. 9-254616

[Date of filed] September 19, 1997

[Indication of a fee]

[Prepayment Register Number] 012313

[The amount of payment] 21,000 YEN

[List of the objects filed]

[Name of the object]	Specification	1
[Name of the object]	Drawings	1
[Name of the object]	Abstract	1

[General Power of Attorney No.] 9703282

[Document Name] SPECIFICATION

[Title of the Invention] IMAGE ENCODER AND IMAGE DECODER

[Claims]

[Claim 1]

An image coding device comprising:

a tile decomposition portion for decomposing image data into tiles each having N pixels x M pixels and outputting the N pixels x M pixels in the tile as an objective data to be coded for a corresponding each of the tile;

a wavelet coding portion for extrapolating a predetermined data at the periphery of the objective data from the tile decomposition portion, decomposing each of the tiles into subbands and separately wavelet-encoding each of the tiles;

a management information generating portion for generating management information necessary for independently decoding coded data of the subbands from the wavelet coding portion on a tile-by-tile basis as well as on the subband-by-subband basis; and

a coded data integrating portion for combining the data separately wavelet-encoded on a tile-by-tile basis according to the management information outputted from the management information generating portion and attaching the management information to the coded data.

[Claim 2]

An image coding device as defined in claim 1, wherein the tile decomposition portion decomposes original image data into

tiles each of the N pixels x M pixels and outputting, as the objective data to be coded corresponding to said each of the tiles, a result of multiplying each of the tiles and neighboring pixel data by a predetermined two-dimensional window function.

[Claim 3]

An image decoding device for receiving coded data coded and inputted by the image coding device of claim 1 and reproducing a desired image by selectively decoding the coded data of necessary tiles and subbands, comprising:

a management information separating portion for separating tile-and-subband management information from input coded data;

a coded data extracting portion for selectively extracting coded data of required objective tiles to be decoded and subbands according to the management information;

a wavelet decoding portion for performing wavelet decoding of the extracted coded data in compliance with the wavelet coding conducted by the image coding device of claim 1; and

a tile combining portion for combining wavelet-decoded tile images into a desirable image.

[Claim 4]

An image decoding device for receiving coded data coded and transmitted by the image coding device of claim 2 and reproducing a desired image by selectively decoding the coded data of necessary tiles and subbands, comprising:

a management information separating portion for separating

tile-and subband management information from the input coded data;

a coded data extracting portion for extracting coded data part corresponding to an objective tile and subbands according to the management information;

a wavelet decoding portion for performing wavelet decoding of the extracted coded data in compliance with the wavelet coding conducted by the image coding device of claim 2; and

a tile integrating portion for arranging wavelet decoded data at respective places on an original image and superposing image values at overlaps of neighboring tiles to integrate the tiles into a desired decoded image.

[Claim 5]

An image coding device comprising:

a tile decomposition portion for decomposing image data into tiles each of N pixels x M pixels and outputting the N pixels x M pixels in the tile as an objective data to be coded for a corresponding each of the tiles;

a adjacent pixel adding portion for providing an objective tile to be coded with adjacent pixels necessary for wavelet transformation of the objective tile to be coded when such pixels exist at the periphery thereof;

a wavelet coding portion for extrapolating a predetermined data when no pixel existing at the periphery of the objective tile to be coded, decomposing each of the tiles into subbands and outputting only wavelet coefficients of the objective tile

to be coded;

a management information generating portion for generating management information necessary for independently decoding coded data outputted from the wavelet coding portion on a tile-by-tile basis as well as on a subband-by-subband basis; and

a coded data integrating portion for combining the data separately wavelet-encoded on a tile-by-tile basis according to the management information outputted from the management information generating portion and attaching the management information to the coded data.

[Claim 6]

An image coding device as defined in claim 5, wherein the each adjacent pixel to be attached to the objective tile is multiplied by a weighting function according to a distance from the objective tile, when each of the objective tiles is attached the adjacent pixel according portion.

[Claim 7]

An image coding device comprising:

a wavelet coding portion for decomposing an image into subbands by extrapolating a predetermined data at the periphery of the image, and performing wavelet encoding of the subbands;

a tile composing portion for reconstructing, from wavelet coefficients inputted from the wavelet coding portion, separate tiles each being composed of N x M wavelet coefficients forming a (membership) set to be separately entropy coded;

a management information generating portion for generating management information necessary for independently decoding coded data outputted from the wavelet coding portion on a tile-by-tile basis as well as on a subband-by-subband basis; and

a coded data integrating portion for composing a sequence of the coded data according to the management information from the management information generating portion and attaching the management information to the coded data.

[Claim 8]

An image decoding device for receiving coded data coded and inputted by the image coding device defined in any of claims 5, 6 and 7 reproducing a desired image by decoding the coded data of necessary tiles and subbands, comprising:

a management information separating portion for separating tile-and subband management information from the input coded data;

a coded data extracting portion for extracting coded data part corresponding to an objective tile and subbands according to the management information;

a wavelet decoding portion for performing wavelet decoding of the extracted coded data in compliance with the wavelet coding conducted by the image coding device defined in any of claims 5, 6 and 7; and

a tile integrating portion for arranging wavelet-decoded data at respective places on an original image and superposing

image values at overlaps of neighboring tables to integrate the tiles into a desired decoded image.

[Claim 9]

An image decoding device for receiving coded data coded and inputted by the image coding device defined in any of claims 5, 6 and 7 and reproducing a desired image by selectively decoding the coded data of necessary tiles and subbands, comprising:

a management information separating portion for separating tile-and subband management information from input coded data;

a coded data extracting portion for selectively extracting coded data of required decodable objective tiles and subbands according to the management information;

a wavelet decoding portion for performing wavelet decoding of the extracted coded data by the coded data extracting portion, and

a wavelet-coefficient rearranging portion for rearranging the wavelet coefficients reconstructed on a tile-by-tile basis by the wavelet decoding portion into an initial order of them before having been tiled.

[Claim 10]

An image coding device as defined in any of claims 1, 2, 5 and 6, wherein the wavelet coding portion is provided with a memory necessary for storing at least data for the tile.

[Claim 11]

An image decoding device as defined in any of claims 3,

4 and 8, wherein the wavelet decoding portion includes a memory for storing data at least for the tile.

[Claim 12]

An image coding device as defined in any of claims 1, 2, 5, 6, 7 and 10, wherein the wavelet-coding portion performs multiple times the subband decomposition process by selectively applying suitable filters for respective subbands.

[Claim 13]

An image decoding device as defined in any of claims 3, 4, 8, 9 and 11, wherein the wavelet decoding portion repeats multiple times the subband composition with use of filters changeable for respective subbands.

[Detailed Description of the Invention]

[0001]

[Technical Field to which the Invention Pertains]

The present invention generally relates to the field of digital image processing and, more specifically, to an image coding device for encoding digital image data with high efficiency and an image decoding device for decoding coded data encoded by the image coding device.

[0002]

[Prior Art]

Flash Pix format specification version 1.0 has been proposed as an image format for converting natural image data into digital data suitable for computer processing.

[0003]

This format specification permits a plurality of data with different resolutions to be stored together therein so that any data suited to an actual display and/or printing device can be selected and taken-out promptly in response to a user's request. Furthermore, each image is divided into tiles arranged in the format that allows the user to select only a necessary data portion of the image and process it in an enlarged or reduced size with a reduced processing load.

[0004]

Referring to Figures 16, an image coding device for encoding an image according to the flash pix format is described as follows. In Fig. 16(a), images are shown in different reduced scales, each of which are divided into tiles. Figure 16(b) is a block diagram of an exemplary image coding device.

[0005]

The flash pix method is featured in that it generates first images 1 to 4 in sizes 1/1 to 1/8, as shown in Fig. 16(a), then divides each image into tiles and compresses data of each tile image.

[0006]

First, a case of encoding an image 1 shown in Fig. 16(a) by the coding device of Fig. 16(b) is described. In Fig. 16(a), a dashed line shows the boundary between tiles.

[0007]

A tile decomposition portion 1601 divides an original image

into tiles each comprising 64 x 64 pixels, which tiles are then compressed one by one by a JPEG compressor portion 1602. In a coded-data integration portion 1603, coded data of each tile is combined with tile decomposition information from the tile decomposition portion 1601 to form coded data 1 to be output.

[0008]

The image 2 of Fig. 16(a) is described. The original image is reduced to 1/2 in length and width by a 1/2 contraction portion 1604, and then the 1/2-size image is processed through a tile decomposition portion 1605, a JPEG compressor portion 1606 and a coded-data integration portion 1607 to form coded data 2.

[0009]

Size reduction of the image to generate a group of size-reduced images in Fig 16(a) (Images 2 to 4) is repeatedly performed until a downsized image containable within a single tile is obtained.

[0010]

For example, the image 3 is still larger than a tile and is further contracted by a factor of 2 to obtain the image 4 allowable within a single tile as shown in Fig. 16(a). The size-reduction procedure is now finished.

Coded data for the image 3 is produced through a 1/2 contraction portion 1608, a tile decomposition 1609, a JPEG compressor portion 1610 and a coded data integration portion 1611. Coded data for the image 4 is produced through a 1/2

contraction portion 1612, a tile decomposition portion 1613, a JPEG compressor portion 1614 and a coded data integration portion 1615.

[0011]

However, the above-described system involves the following problems: Storing coded data for images downsized with different resolutions in addition to coded data for the image with the scale 1:1 results in increasing a volume of coded data by a factor of 1.4. Furthermore, compression for encoding data must be done for each resolution image, resulting in considerably increasing processing load.

[0012]

On the other hand, apart from the Flash Pix method, the image compression can be also accomplished by the wavelet transform technique whereby image data with different resolutions can be easily decoded from coded and compressed data of an original-size image. This technique is therefore free from the problem with increasing the amount of coded data.

[0013]

Namely, the wavelet transform method can meet the demand for decoding data with different resolutions without any increase by a factor 1 in volume of coded data whereas the Flash Pix method has an increase by a factor of 1.4 in volume of coded data.

[0014]

Figure 17 is a basic block diagram of a wavelet transform

coding portion wherein an original image is converted by a wavelet transform portion 1701 into data for subband divisions, which data is quantized by a quantizing portion 1702 and then entropy encoded by an entropy coding portion 1703 to produce coded data.

[0015]

Figure 18 is a detailed block diagram of the wavelet transform portion 1701 of Fig. 17.Figure 19 depicts an example of the wavelet transformation of an image in case of conducting two-dimensional subband decomposition three times.

[0016]

An original image shown in Fig. 19(a) is filtered through a horizontal low-pass filter 1801 and a horizontal high-pass filter 1802 to create two horizontal subbands that are then decimated to 1/2 respectively by 1/2-subsampling portions 1807 and 1808.

[0017]

Two horizontally divided subbands are divided each into two subbands through vertical low-pass filters 1803, 1805 and vertical high-pass filter 1804, 1806, which subbands are decimated each to 1/2 by 1/2 sampling portions 1809 to 1812. Consequently, four subbands are formed.

[0018]

A high-horizontal and high-vertical frequency subband "ヌ" (Fig.18), a high-horizontal and low-vertical frequency subband "リ" (Fig. 18) and a low-horizontal and high-vertical

frequency subband "チ" (Fig. 18) correspond to wavelet transform coefficients "チ", "リ" and "ヌ" (Fig.19(b)) respectively.

[0019]

After this, only a remaining low-horizontal and low-vertical frequency subband 1813 is recursively divided into subbands.

[0020]

This recursive subband decomposing process is performed by horizontal low-pass filters 1814, 1826, horizontal high-pass filters 1815, 1827, vertical low-pass filters 1816, 1818, 1828, 1830, vertical high-pass filters 1817, 1819, 1829, 1831 and 1/2-sampling portions 1820-1825, 1832-1837.

[0021]

Sub-bands "イ"-"ト" (Fig. 18) correspond to sub-bands "イ"-"ト" (Fig.19(b)) respectively.

[0022]

Wavelet transform coefficients shown in Fig. 19(b) are quantized on a subband-by-subband basis by a quantizing portion 1702 (Fig. 17) and then entropy encoded by an entropy coding portion 1703 to produce coded data. The entropy-coding portion 1703 may use Huffman coding or arithmetic coding.

[0023]

On the other hand, wavelet-coded data is decoded by an entropy decoding portion 2001 and inversely quantized by an inverse quantizing portion 2002. Subbands are then combined by an inverse wavelet transform portion 2003 to produce a

decoded image (Fig. 20).

[0024]

Image-encoding using the wavelet transform technique is featured by hierarchical structure according to resolution levels as shown in Fig. 19(b). This method can easily decode images having different resolution levels from a part of coded data or a whole coded data.

[0025]

Namely, an image of a quarter (1/4) the original image size can be decoded by decoding subbands "イ", "ロ", "ハ" and "ニ" in Fig.19(b). an image of a half (1/2) the original image size can be decoded by decoded subbands "イ", "ロ" ,"ハ", "ニ", "ホ", "ヘ" and "ト". A complete (1/1) size image can be produced by decoding all subbands.

[0026]

Referring to Fig. 21, the operation of the horizontal low-pass (H-LP), horizontal high-pass (H-HP), vertical low-pass (V-LP) and vertical high-pass (V-HP) filters shown in Fig. 18 will be described as follows. Figure 21(b) is an enlarged view of an encircled part of Fig. 21(a).

[0027]

When an output of a horizontal 9 tap filter, associated with a pixel 2101 positioned right top on the original image is calculated for wavelet transformation of an original image, the operation of the filter must be performed on an area 2101.

[0028]

However, a part of the objective area 2102 is out of the boundary of the original image, where no data exists. The vertical filters may also encounter with a similar problem.

[0029]

Thus, for operation on the periphery of the image, it is often needed to use external data outside the image boundary according to the number of the taps of the filter used. Iteration of the subband decomposition also results in enlarging the area into which the filter extrudes.

[0030]

In general, the above problems are treated in such a manner that the image is folded at its periphery according to a certain given rule.

[0031]

[Problems to be solved by the Invention]

For the Flash Pix method using a plurality of coded data sets separately provided for respective images of different resolution levels, the image processing load such as enlargement or contraction of the image can be reduced, but the data size is increased to 1.4 times.

[0032]

For wavelet-transform coding method, data with different resolution levels can be easily decoded from a single set of compressed and coded data for an original image size and, therefore, no increase in the data size takes place.

[0033]

When the wavelet-transform coding system utilizes the method of decomposing an image into tiles and encoding the image data on a tile-by-tile basis, which is used in the flash-pix system (to reduce the processing load by selectively processing only necessary tiles in case of processing a particular part of the image), however, this arises the above-described problem since filters may stick from the boundary of respective tiles.

[0034]

In other words, the flash pix system using the JPEG coding can easily perform coding of each tile owing to the closed property of coding in each tile, while the wavelet-transform coding system can not effectively use the above tile-by-tile coding-and-managing method because the processing causes the extrusion of filters out of respective tiles.

[0035]

In addition, the conventional wavelet-transform coding system must have a memory sufficient for storing an output of the wavelet-transform portion 1701 (Fig. 17), i.e., all wavelet transform coefficients as shown in Fig. 19(b). Since these coefficients have the same resolution as that of the original image, the memory has to possess a large capacity. This requirement becomes severer when processing a higher resolution image.

[0036]

In view of the above-described problems of the prior arts, the present invention was made to provide a compact hardware

system that realizes effective encoding of images with different resolutions and effective management of coded data by tiles by using an improved wavelet-transform technique.

[0037]

[Means for solving Problem]

(1) An object of the present invention is to provide an image coding device comprising:

a tile decomposition portion for decomposing image data into tiles each having N pixels x M pixels and outputting the N pixels x M pixels in the tile as an objective data to be coded for a corresponding each of the tile;

a wavelet coding portion for extrapolating a predetermined data at the periphery of the objective data from the tile decomposition portion, decomposing each of the tiles into subbands and separately wavelet-encoding each of the tiles;

a management information generating portion for generating management information necessary for independently decoding coded data of the subbands from the wavelet coding portion on a tile-by-tile basis as well as on the subband-by-subband basis; and

a coded data integrating portion for combining the data separately wavelet-encoded on a tile-by-tile basis according to the management information outputted from the management information generating portion and attaching the management information to the coded data.

[0038]

(2) Another object of the present invention is to provide an image coding device having means as defined in above item (1), wherein the tile decomposition portion decomposes original image data into tiles each of the N pixels x M pixels and outputting, as the objective data to be coded corresponding to said each of the tiles, a result of multiplying each of the tiles and neighboring pixel data by a predetermined two-dimensional window function.

[0039]

(3) Another object of the present invention is to provide an image decoding device for receiving coded data coded and inputted by the image coding device having means as defined in the above item (1) and reproducing a desired image by selectively decoding the coded data of necessary tiles and subbands, comprising:

a management information separating portion for separating tile-and-subband management information from input coded data;

a coded data extracting portion for selectively extracting coded data of required decodable objective tiles and subbands according to the management information;

a wavelet decoding portion for performing wavelet decoding of the extracted coded data in compliance with the wavelet coding conducted by the image coding device of claim 1; and

a tile combining portion for combining wavelet-decoded tile images into a desirable image.

[0040]

(4) Another object of the present invention is to provide an image decoding device for receiving coded data coded and transmitted by the image coding device having means as defined in above item (2) and reproducing a desired image by selectively decoding the coded data of necessary tiles and subbands, comprising:

a management information separating portion for separating tile-and subband management information from the input coded data;

a coded data extracting portion for extracting coded data part corresponding to an objective tile and subbands according to the management information;

a wavelet decoding portion for performing wavelet decoding of the extracted coded data in compliance with the wavelet coding conducted by the image coding device of claim 2; and

a tile integrating portion for arranging wavelet decoded data at respective places on an original image and superposing image values at overlaps of neighboring tiles to integrate the tiles into a desired decoded image.

[0041]

(5) Another object of the present invention is to provide an image coding device comprising:

a tile decomposition portion for decomposing image data into tiles each of N pixels x M pixels and outputting the N pixels x M pixels in the tile as an objective data to be coded

for a corresponding each of the tiles;

a adjacent pixel adding portion for providing an objective tile to be coded with adjacent pixels necessary for wavelet transformation of the objective tile to be coded when such pixels exist at the periphery thereof;

a wavelet coding portion for extrapolating a predetermined data when no pixel existing at the periphery of the objective tile to be coded, decomposing each of the tiles into subbands and outputting only wavelet coefficients of the objective tile to be coded;

a management information generating portion for generating management information necessary for independently decoding coded data outputted from the wavelet coding portion on a tile-by-tile basis as well as on a subband-by-subband basis; and

a coded data integrating portion for combining the data separately wavelet-encoded on a tile-by-tile basis according to the management information outputted from the management information generating portion and attaching the management information to the coded data.

[0042]

(6) Another object of the present invention is to provide an image coding device having means defined in the above item (5), wherein the each adjacent pixel to be attached to the objective tile is multiplied by a weighting function according to a distance from the objective tile, when each of the

objective tiles is attached the adjacent pixel according portion.

[0043]

(7) Another object of the present invention is to provide an image coding device comprising:

a wavelet coding portion for decomposing an image into subbands by extrapolating a predetermined data at the periphery of the image, and performing wavelet encoding of the subbands;

a tile composing portion for reconstructing, from wavelet coefficients inputted from the wavelet coding portion, separate tiles each being composed of N x M wavelet coefficients forming a (membership) set to be separately entropy coded;

a management information generating portion for generating management information necessary for independently decoding coded data outputted from the wavelet coding portion on a tile-by-tile basis as well as on a subband-by-subband basis; and

a coded data integrating portion for composing a sequence of the coded data according to the management information from the management information generating portion and attaching the management information to the coded data.

[0044]

(8) Another object of the present invention is to provide an image decoding device for receiving coded data coded and inputted by the image coding device having means as defined in any of the above items (5), (6) and (7) reproducing a desired

image by decoding the coded data of necessary tiles and subbands, comprising:

a management information separating portion for separating tile-and subband management information from the input coded data;

a coded data extracting portion for extracting coded data part corresponding to an objective tile and subbands according to the management information;

a wavelet decoding portion for performing wavelet decoding of the extracted coded data by the image coding device; and

a tile integrating portion for arranging wavelet-decoded data at respective places on an original image and superposing image values at overlaps of neighboring tables to integrate the tiles into a desired decoded image.

[0045]

(9) Another object of the present invention is to provide an image decoding device for receiving coded data coded and inputted by the image coding device having means as defined in any of the above items (5), (6) and (7) and reproducing a desired image by selectively decoding the coded data of necessary tiles and subbands, comprising:

a management information separating portion for separating tile-and subband management information from input coded data;

a coded data extracting portion for selectively extracting coded data of required decodable objective tiles and subbands according to the management information;

a wavelet decoding portion for performing wavelet decoding of the extracted coded data by the image coding device; and

a wavelet-coefficient rearranging portion for rearranging the wavelet coefficients reconstructed on a tile-by-tile basis by the wavelet decoding portion into an initial order of them before having been tiled.

[0046]

(10) Another object of the present invention is to provide an image coding device having means as defined in any of the above items (1), (2), (5) and (6), wherein the wavelet coding portion is provided with a memory necessary for storing at least data for the tile.

[0047]

(11) Another object of the present invention is to provide an image decoding device having means as defined in any of the above items (3), (4) and (8), wherein the wavelet decoding portion includes a memory for storing data at least for the tile.

[0048]

(12) Another object of the present invention is to provide an image coding device having means as defined in any of the above items (1), (2), (5), (6), (7) and (10), wherein the wavelet-coding portion performs multiple times the subband decomposition process by selectively applying suitable filters for respective subbands.

[0049]

(13) Another object of the present invention is to provide an image decoding device having means as defined in any of the above items (3), (4), (8), (9) and (11), wherein the wavelet decoding portion repeats multiple times the subband composition with use of filters changeable for respective subbands.

[0050]

[Modes for carrying out the Invention]

Figure 1is a block diagram showing the construction of an image coding device that is an embodiment 1 of the present invention.

[0051]

Image data of an original image as shown in Fig. 2(a) is decomposed by a tile decomposition portion 101 into tiles each of predetermined N pixels by M pixels. The decomposed image is shown in Fig. 2(b). The tile decomposition portion 101 outputs N pixels by M pixels image in a tile as corresponding data to each tile.

[0052]

Further processing will be described by way of example on a tile "i" in Fig. 2(b). Image data of the tile "i" is divided by a wavelet transform portion 102 into subbands.

[0053]

Data at the periphery of a tile is extrapolated when dividing the tile portion near its boundary into subbands. For example, as shown in Fig. 21(b), an area 2102 covered by a

wavelet transform filter exists out of a tile. In this case, it is needed to add data at the periphery of the tile. The wavelet transform portion 102 therefore extrapolates data at the periphery of each tile and divides the tile into subbands.

[0054]

The data extrapolation is achieved for example by generating a mirror image by outwardly folding an internal image of the tile as shown in Fig. 2(c). A quantizing portion 103 quantizes wavelet transform coefficients and an entropy coding portion 104 performs entropy coding of the coefficients to obtain coded data of the tile "i".

[0055]

The entropy coding can be achieved by using a known Huffman coding method or arithmetic coding method. The wavelet transform portion 102, quantizing portion 103 and entropy coding portion 104 composes a so-called wavelet-transform coding portion 105.

[0056]

On the other hand, a management information generating portion 106 generates information for identifying and managing tiles and subbands by using information on spatial locations of each tile from the tile decomposition portion 101 and information on each subband from the wavelet-transform coding portion 105. The management information is utilized by a coded data integration portion 107.

[0057]

Using the management information from a management information generating portion 106, the coded data integration portion 107 arranges and integrates information on the coded data from the entropy coding portion and adds the management information to a bit stream to generate coded data.

[0058]

Management of the coded data according the tiles and subbands is needed for achieving decoding of a coded image at different resolution levels as shown in Fig. 16(a) or a particular tile or tiles of the coded image.

[0059]

Figure 3 shows an example of a bit stream of coded data produced in the above-described manner. The bit stream is composed of a header for managing information on a whole bit stream and data on each tile. Information for each tile consists of a tile header for managing the tile information and coded data representing a tile image encoded by the wavelet transform coding portion.

[0060]

The tile header includes information on bit positions corresponding to respective subbands. A bit sequence corresponding to necessary one of the subbands can be found by accessing this information.

[0061]

The structure of bit streams used in the system of the present invention is not limited to that shown in Fig. 3. For

instance, the tile header could include all information of itself. Decoding of bit stream in Fig. 3 will be described later.

[0062]

An image coding device according another embodiment 2 of the present invention will be described as follows. The image coding device of the embodiment 2 is similar in construction to the embodiment 1 shown in Fig. 1 but differs from the embodiment 1 described above with the figure 1 by the operation of the tile decomposition portion, which will be described below with reference to Fig. 13.

[0063]

While the tile decomposition portion of the embodiment 1 decomposes an image into tiles each of N pixels by M pixels and outputs only image data within each tile to the wavelet transform portion 102, the tile decomposition portion of embodiment 2 outputs image data obtained by multiplying the original image by a suitable window function.

[0064]

For example, in case of extracting a tile "ij" in fig. 13, the output of the tile decomposition portion 101 is a result of multiplying the original image data by a window function FX_i in the horizontal direction and by a window function Fy_j in the vertical direction. i denotes a horizontal tile number and j denotes a vertical tile number.

[0065]

This means that the output of the tile decomposition portion represents a weighted result of multiplying a shaded image portion (Fig. 13) by a weight corresponding to window functions. Window functions are such that a total of functions over a whole area is equal to 1. Window functions satisfying the following conditions are used.

$\Sigma FX_i(x)=1 \quad (0 \leqq x \leqq w)$

$\Sigma FY_j(y)=1 \quad (0 \leqq y \leqq h)$

where, w is the width of the original image, h is the height of the original image, x and y are the axes of abscissa and ordinate, respectively, with the origin at the top right corner of the original image.

A total of the functions $FX_i(x)$ is taken for i and $FY_j(y)$ is taken for j. In Fig. 13, FX_{i-1}, FX_i, FXY_i, FY_j, FY_{j+1} are exemplary functions satisfying the above conditions.

[0066]

In consequence of the extraction of data by applying window functions, the output of the tile decomposition portion 101 includes pixels of a tile ij plus peripheral pixels weighted with the window function values.

[0067]

An image decoding device for decoding coded data from the image coding device of the embodiment 1 will be now described as an embodiment 3 of the present invention. Figure 4 is a block diagram of the image decoding device according to the embodiment 3.

[0068]

The image decoding device receives coded data from the image coding device described as the embodiment 1 of the present invention. A management data separating portion 401 takes out information for managing tiles and subbands from the received coded data.

[0069]

A coded data extracting portion 402 selectively extracts coded data of necessary tile and subbands according to the user's request.

[0070]

In the exemplary bit stream shown in Fig. 3, the management information is found in the header and the tile header.

[0071]

The extracted coded information is entropy-decoded by an entropy decoding portion 403 and inversely quantized by an inverse quantizing portion 404 to produce wavelet-transform coefficients corresponding to the tile to be decoded.

[0072]

The wavelet-transform coefficients are inversely transformed by an inverse wavelet transform portion 405 to produce a decoded image of the objective tile. The entropy-decoding portion 403, inverse quantizing portion 404 and inverse wavelet-transform portion 405compose a so-called wavelet-transform decoding portion 406.

[0073]

A tile combining portion 407 combines together decoded tiles according to the tile managing information from the Management Information Separating Portion 401 to generate a decoded image of the desired area or at a desired resolution.

[0074]

The decoding process with the bit stream shown in Fig. 3 is as follows. To decode a low-resolution entire image (all tiles), coded data (1-a, 2-a, …, i-a, …), which correspond to low-resolution subbands, are decoded in order in respective tile by the wavelet-transform decoding portion 406 according to the tile with referring to subband information included in each tile header.

[0075]

The low-resolution decoded tiles are then combined by the tile-combining portion 407, thereby a whole low-resolution image is reproduced.

[0076]

From the low-resolution decoded image, a particular tile "i"(that means representation with high resolution) can also be reproduced in an enlarged scale with the highest resolution by decoding all the coded information of the i-th tile which correspond to the tile image "i".

[0077]

Namely, coded data i-b extracted and decoded together with already extracted coded information i-a to obtain the desired decoded image. It is, of-course, possible to reproduce a

high-resolution decoded image of all areas by decoding all coded data (all tiles including all subbands).

[0078]

Thus, the image decoding device can easily decode any resolution image and/or any tile (partial) image can be easily decoded according to the user's request.

[0079]

An image decoding device according to another embodiment 4 corresponding to the claim 4 is as follows:

Coded data is input from the image coding device according to the embodiment 2 of the present invention. This image decoding device is similar in construction to the embodiment 3 shown in Fig. 4 and differs from the latter by the operation of the tile-combining portion 407, which will be described below with reference to Fig. 15.

[0080]

In the image coding device according to the embodiment 2, pixels of each tile have been encoded together with pixels at its periphery. Therefore, data of a tile decoded in a wavelet-transform decoding portion 406 of this image decoding device is larger than an actual tile.

[0081]

In Fig. 15, a tile is composed of 2 x 2 pixels and the data size of a decoded tile is of 4 x 4 pixels. In this case, decoded data of a tile ij has an area shaded in Fig. 15, which overlaps neighbors each by one pixel width.

[0082]

The tile-combining portion determines a pixel value for each overlap by adding together decoded data thereat when linking the decoded tiles. For example, the value of a pixel "a" in Fig. 15 is calculated as follows:

$a(i-1,j-1)+a(i,j-1)+a(i-1,j)+a(i,j)$

where $a(i,j)$ represents decoded data of the tile ij at the position of its pixel "a".

[0083]

An image coding device according to another embodiment 5 of the present invention will be described with reference to Fig. 5 showing its construction.

[0084]

This image coding device differs from the image coding device (embodiment 1) of Fig. 1 by the fact that it does not unconditionally conduct extrapolation of data at the periphery of an objective tile and utilizes another tile adjacent to the tile if such exists.

[0085]

Like the embodiment 1, this image coding device decomposes an original image into tiles as shown in Fig. 6(a) at its tile decomposition portion 501 shown in Fig. 15. The image coding device further processes a tile "i" of the image as follows: In a wavelet-transform coding portion 503, image data of the tile "i" is wavelet-transformed through a wavelet-transform filter. In this case, if the filter extrudes from the tile "i"

into neighboring tiles and covers part of pixels contained in the neighbors, image data of those pixels in the neighbors are also wavelet-transformed together with the image data of the objective tile "i" by the filter.

[0086]

Referring to Fig. 6, the objective tile "i" of Fig. 6(a) is extended by adding necessary shaded parts of neighboring tiles "イ"-"チ" as shown in Fig. 6(b) and then wavelet-transformed.

[0087]

A adjacent pixel adding portion 502 realizes the above process by recognizing neighboring tiles around the objective tile according to the tile decomposition information from the tile decomposition portion 501 and by adding necessary pixels if the neighbors exist.

[0088]

Then, the tile image data added necessary peripheral pixels by the above adjacent adding portion is decomposed into subbands through the wavelet transform portion 503. When the object tile to be coded is at the edge of the image, data is extrapolated to the part which couldn't be added the necessary adjacent pixels to and decomposed into subbands. This data extrapolation is achieved by generating a mirror image like the embodiment 1.

[0089]

The wavelet transform portion generates wavelet transform

coefficients of pixels included within the objective tile "i" using only for calculation purpose of wavelet transform coefficients of the pixels added thereto by the peripheral pixel adding portion 502.

[0090]

A quantizing portion 504 quantizes the wavelet transform coefficients and an entropy coding portion 505 performs entropy encoding of the quantized coefficients to obtain coded information of the objective tile "i". The wavelet transform portion 503, quantizing portion 504 and entropy-coding portion 505 composes a so-called wavelet transform coding portion 506.

[0091]

On the other hands, a management information generating portion 507 receives spatial-tile-position information from the tile decomposition portion 501 and subband information from the wavelet transform coding portion 506 and generates management information for managing and identifying tiles and subbands. The management information is used by a coded-data integrating portion 508.

[0092]

The coded data integrating portion 508 rearranges and integrates coded information outputted from the entropy coding portion 505 according to the management information outputted from the management portion 507 and then adds the management information to a bit stream to generate a final coded data (for example in Fig. 3).

[0093]

An image coding device according to still another embodiment 6 of the present invention will be described below:

This image coding device is similar in construction to the device of the embodiment 5 described above with reference to Fig. 5 but differs from the latter only by the operation of its peripheral-pixel adding portion. The operation of the peripheral-pixel adding potion is described below with reference to Fig. 14.

[0094]

An objective tile "i" in Fig. 14 is now processed by way of example as follows:

In the embodiment 5, the peripheral-pixel-adding portion 502 added to a tile "i" all pixels necessary for calculating wavelet-transform coefficients for pixels in the objective tile, that is, pixels in areas covered by a filter extending from the objective tile. The adjacent pixel areas are shown as shaded in Fig. 14.

[0095]

Since distant pixels have a small effect on wavelet transform coefficients in a tile "i", the embodiment 6 adds a result of multiplying peripheral pixels by a suitable weighing function to the tile "i" to reduce the number of pixels to be attached, i.e., lighten the computation work load.

[0096]

The weighting function is 1 for each pixel near the tile

"i" and has a distance-depending value approaching to zero as a distance from the tile "i" increases. In Fig. 14, there is an example of a weighting function. Pixels multiplied by the weighting function and actually added to the objective tile compose an effective pixel area mesh-dotted in Fig. 14. A peripheral pixel area shown as shaded only in Fig. 14 is necessary for wavelet transform calculation but is not added because its weighted value is zero.

[0097]

Alternatively, a stepwise weighting function may be applied, which is given 1 for each pixel within a specified distance from the tile "i" and 0 for all pixels existing over the specified distance.

[0098]

Another image coding device is described as an embodiment 7 corresponding to the claim 7.

[0099]

Figure 7 is a block diagram of an image coding device according to the embodiment 7.

This image coding device differs from the embodiment 1 of Fig. 1 and the embodiment 5 of fig. 5 by the fact that an original image is entirely wavelet-transformed by a wavelet transform portion 701 and, then, wavelet transform coefficients outputted from the wavelet transform portion 701 are rearranged per tile to compose respective tiles.

[0100]

An original image before tiling is wavelet-transformed by a wavelet transform portion 701. A tile composing portion 702 composes tiles by rearranging wavelet transform coefficients so that a tile is composed of coefficients spatially matching the same tile. Figure 8(a) shows an example of subbands obtained by wavelet transform portion 701. In the shown case, a coefficient b0 in the lowest frequency subband spatially correlates with other subband coefficients b1, b2, b3, b4, b5, b6, b7, b8 and b9.

[0101]

Where b1-b3 consist each of 1x1 coefficient, b4-b6 consist each of 2x2 coefficients and b7-b9 consist each of 4x4 coefficients. These coefficients b0-b9 are taken out of the respective subbands and then arranged to compose a single tile as shown in Fig. 8(b). Likewise, all other wavelet transform coefficients are arranged to compose respective tiles. This results in obtaining the same result as in the embodiment 5 whereby an original image is first decomposed into portion tiles and then wavelet transformed.

[0102]

b0 is not necessarily a single coefficient, but it may be a block composed of k x l coefficient. In this case, b1-b3 consist each of k x l, b4-b6 consist each of 2k x 2l and b7-b9 consist each of 4k x 4l coefficients.

[0103]

Wavelet transform coefficients organized per tile are

outputted from the wavelet transform portion 702. They are quantized by a quantizing portion 703 and entropy-encoded by an entropy-coding portion 704, thus coded data is generated.

[0104]

On the other hand, a management-information generating portion 706 generates management information necessary for managing and identifying tiles and subbands using spatial-tile-location information from the tile composing portion 702 and subband-location information from the wavelet transform coding portion 705. The management information is used by a coded-information integrating portion 707.

[0105]

The coded information integrating portion 707 receives the management information from the management information generating portion 706and the coded data from the entropy-coding portion 704 and it arranges and combines the entropy coded information and adds management information in a bit stream of the coded data, thus generating finally coded data (in Fig. 3).

[0106]

Although the tile-composing portion 702 is installed before the quantizing portion 703 in this embodiment, it is not limited to this arrangement and may be placed after the quantizing portion 703.

[0107]

An image decoding device for decoding data encoded by any

one of the above-described image coding devices (embodiment 5 to 7) is now described below as an embodiment 8 of the present invention.

[0108]

Figure 9 is a block diagram showing the construction of the image decoding device according to the embodiment 8 corresponding to the claim 8. The decoding device receives coded data encoded by any one of the image coding devices described above as embodiments 5 to 7.

[0109]

The image decoding device separately takes out tile-decomposition management information and subband-management information from the input coded-data stream by a management information separating portion 901 and selectively extracts a necessary part of the coded information meeting the user's demand by a coded data extracting portion 902 according to the management information. Namely, the coded data corresponding to a necessary objective tile(s) having a necessary resolution is extracted by the coded data extracting portion 902.

[0110]

The extracted coded information is entropy-decoded by an entropy decoding portion 903 and inversely quantized by an inverse quantizing portion 904. Thus, wavelet transform coefficients corresponding to an objective tile to be decoded are now obtained.

[0111]

The wavelet transform coefficients inversely transformed by an inverse wavelet transform portion 905, thereby a decoded image including peripheral pixels data is produced. The entropy coding portion 903, the inverse quantizing portion 904 and the inverse wavelet transform portion 905 compose a so-called inverse wavelet transform decoding portion 906.

[0112]

A tile combining portion 907 integrates groups of the decoded tiles according to the management information from the management information-separating portion 901. In this case, a completely decoded image is reproduced with overlaps of decoded tile images at each spatially overlapped portion.

[0113]

Namely, the embodiment 2 described above with reference to Fig. 13 performed wavelet transform of each tile with adjacent pixels attached thereto. The embodiment 5 uses adjacent pixels in performing wavelet transform of each tile as shown in Fig. 6(b). Likewise, the embodiment 6 described with reference to Fig. 14 also uses peripheral pixels in wavelet transform of each tile.

[0114]

In the image coding device according to the embodiment 7, the process using adjacent pixels is not clearly described but the wavelet transform of a whole original image has been done including the processing theoretically equivalent to that made in the embodiment 5.

[0115]

Therefore, data of peripheral pixels is produced when each tile image is decoded by the wavelet transform decoding portion in Fig. 9 and the decoded adjacent pixels are superposed on respective neighboring tiles by the tile combining portion 907. The superposition of one pixel on another is achieved by additive operation on the pixels.

[0116]

Another image decoding device is described below as an embodiment 9 corresponding to the claim 9. Like the above embodiment 8, the input to this embodiment 9 is coded data encoded by any one of the image coding devices being the embodiments 5 to 7. Figure 10 is a block diagram showing the construction of the image coding device according to the embodiment 9.

[0117]

A management information separating portion 1001 separately takes out tile-division management information and subband management information from the input coded-data stream, and a coded data extracting portion 1002 selectively extracts a necessary part of the coded information meeting the user's demand according to the management information. Namely, the coded data corresponding to a necessary objective tile(s) having a necessary resolution is extracted by the coded data extracted portion 1002.

[0118]

The extracted coded information is entropy-decoded for each tile by an entropy decoding portion 1003 and inversely quantized by an inverse quantizing portion 1004. Wavelet transform coefficients corresponding to an objective tile to be decoded are thus obtained. A wavelet transform coefficient rearranging portion 1005 rearranges the wavelet transform coefficients into the state in which they were placed before tile-by-tile arrangement.

[0119]

Namely, the wavelet transform coefficients divided per tile as shown in Fig. 8(b) are rearranged in the state shown in Fig. 8(a). After completion of processing on all tiles, all wavelet transform coefficients of Fig. 8(a) are obtained.

[0120]

The rearranged wavelet transform-coefficients can be decoded at a time by inverse transformation. Namely, the coefficients are inversely transformed by an inverse wavelet transform portion 156, thereby a whole decoded image is reproduced.

[0121]

The entropy coding portion 1003, the inverse quantizing portion 1004 and the inverse wavelet transform portion 1007 compose a so-called inverse wavelet transform decoding portion 1007. Although the wavelet transform coefficient rearranging portion 1005 is installed after the inverse quantizing portion 1004 in this embodiment, it is not limited to this arrangement

and may be placed before the inverse quantizing portion 1004.

[0122]

An image coding device is described below as an embodiment 10 corresponding to the claim 10.

[0123]

Figure 11(e) is a block diagram of a portion of this embodiment, which responds to the wavelet transform portion (102 in Fig. 1, 503 in Fig. 5) of the image coding devices according to the embodiments 1, 2, 5 and 6.

[0124]

Referring to Fig. 11(e), a memory 1102 is used for storing wavelet transform coefficients divided into subbands by a wavelet transform portion 1101. In this case, the memory 1102 stores only wavelet transform coefficients corresponding to a tile being currently processed by the wavelet transform portion 1101. The processed data are transferred to a quantizing portion (103 in Fig. 1, 504 in Fig. 5) following the wavelet transform portion 1102.

[0125]

Therefore, the memory 1102 has no need to store all data for a whole image and is sufficient to store such an amount of data necessary for processing only one tile.

[0126]

Namely, if wavelet-transformation without tile decomposition is applied to a whole image as shown in Fig. 11(a), it is necessary to store all wavelet transform coefficients

(Fig. 11(b)) outputted from the wavelet transform portion 1101. In contrast to the above, the decomposition of an image into tiles as shown in Fig. 11(c) enables the coding device to use a memory for storing only wavelet transform coefficients corresponding to a small image of Fig. 11(d), thus realizing a considerable saving of the memory capacity.

[0127]

The same effect can be realized in an image decoding device. An image decoding device is described below as another embodiment 11 of the present invention. Figure 12(e) is a block diagram, which corresponds to the inverse wavelet transform portion (405 in Fig. 4, 905 in Fig. 9) of the image decoding devices described before as the embodiments 3, 4 and 8.

[0128]

Referring to Fig. 12(e), a memory 171 stores wavelet transform coefficients necessary for decoding one tile and an inverse wavelet transform portion 1202 performs the composition of subbands.

[0129]

An image that must be decoded is assumed to be that shown in Fig. 12(b). When performing the wavelet transform of the image without decomposition into tiles, it is necessary to store all wavelet transform coefficients as shown in Fig. 12(a). On the contrary, when decoding an image decomposed into tiles as shown in Fig. 12(d), the image decoding device can operate using a memory 1201 storing the limited number of wavelet

transform coefficients as shown in Fig. 12(c). The necessary memory capacity can be considerably saved.

[0130]

All the above-described embodiments can be provided with a plurality of subband-decomposition filters that are adaptively switched over one another to use in the process of wavelet transform coding (claim 12).

[0131]

The subband decomposition filters are low-pass filters and high-pass filters for decomposing an image into subbands as described before for the prior art devices. The subband decomposition process is iterated for wavelet transformation. Filters to be used for this purpose are of various types having different numbers of taps and different coefficient values.

[0132]

Accordingly, it is desirable to selectively apply suitable one of filters to each subband-decomposition because this enables the coding device to change a necessary amount of adjacent pixels for an objective image by applying a suitable filter for a current subband. Optimal wavelet transformation of an image may be achieved by finding a reasonable compromise between the processing data amount and the image quality.

[0133]

In image decoding devices responding to such image coding devices, each subband composition filters responding to respective subband decomposition filters used for wavelet

transformation are selectively used for each of subbands to be combined through inverse wavelet transformation.

[0134]

[Effect of the Invention]

Accordingly, an object of the present invention is to provide an image coding and decoding system by which the image is effectively encoded and easily decoded with any resolution level desired by the user with no increase in volume of coded data.

[0135]

This is a great advantage of the present invention system as compared with the conventional Flash Pix system using the JPEG coding method, which has an increased amount to 1.4 times of code data to provide a plurality of images having different resolutions.

[0136]

Another object of the present invention is to provide an image-coding and decoding system in which an image is decomposed into tiles and encoded on a tile-by-tile basis and the coded tiles can selectively decoded on the same principle by using the wavelet-transform coding/decoding technique. This could not be accomplished by the conventional wavelet-transform coding/decoding system because it is difficult in principle to apply the wavelet transform to closed tiles of the image.

[0137]

In one aspect of the present invention, an image coding device as defined the claim 1 can independently encode each of tiles of an original image, thus providing coded tile images that can be separately treated thereafter. If any of coded tiles must be further processed, it can be separately decoded, processed and encoded again with no need of using adjacent pixels. Thus, simple independent encoding and decoding of image tiles is realized.

In another aspect of the present invention, an image decoding device can decode only a desirable coded tile image with no need of decoding any other coded data, thereby minimizing the processing load.

[0138]

In another aspect of the present invention, in spite of increasing of the coded-data size due to encoding an objective tile image including adjacent pixels by the coding device as defined in the claim 2, an image decoding device as defined in the claim 4 decodes the coded tile image by superposing adjacent pixel values on overlaps, suppressing possible boundary distortion of the tile image.

[0139]

In still another aspect of the present invention, an image coding device as defined in any of claims 5 to 7 and image decoding device as defined in any of claims 8 and 9 can encode tile images using pixel information on neighboring tiles, achieving high efficiency of image encoding using the

correlation between tiles. This can also suppress possible boundary distortion of the tile images.

[0140]

In another aspect of the present invention, an image coding device as defined in the claim 5 can effectively encode a part (plural tiles) of a whole image by performing wavelet transform of only selected tiles. Wavelet transform is very compact.

An image decoding device as defined in the claim 8 responding to the above can also realize compact inverse wavelet transform of coded tile images.

[0141]

In a further aspect of the present invention, an image coding device as defined in the claim 6 can decide elimination of distant pixels from the scope of pixel value calculation for using information of peripheral pixels. This minimizes the number of filtering operations and wavelet-transform operations.

[0142]

A whole image is wavelet transformed at a time by a coding device as defined in the claim 7 and then wavelet transform coefficients are rearranged to compose respective tiles. This eliminates the need of iterating the wavelet-transform for each tile.

In another aspect of the present invention, an image decoding device as defined in the claim 9 can rearrange coded data (decomposed for each tile) corresponding to an objective

tile and then perform inverse wavelet transform of the coded data at a time, thus eliminating the need of repeating inverse wavelet transform for each tile.

[0143]

Conventional arts demand a large capacity of a memory for holding wavelet transformed coefficients to correspond to resolution of an original image. In contrast to the above, an image coding device according to the claim 10 can use, irrespective of the original image size, a memory which can store only wavelet transform coefficients for capacity corresponds to the size of a tile or tiles for a tile or tiles being currently encoded. This can realize a considerable saving of memory capacity needed.

In another aspect of the present invention, an image decoding device as defined in the claim 11 can also use a memory having the capacity limited to a tile size for storing wavelet transform coefficients.

[0144]

In a further aspect of the present invention, an image coding device as defined in the claim 12 can conduct wavelet transform by selectively applying plural suitable filters for decomposing an objective tile image into subbands, thus realizing optimal wavelet transform of the objective tile with the best balance between the image quality and the processing load.

In a further aspect of the present invention, an image

decoding device can conduct inverse wavelet transform by selectively applying plural suitable filters for composing subbands, which filters must respond to the subband decomposing filters. Thus, the device realizes the optimal inverse wavelet transform of each tile to be decoded.

[Brief Description of the Drawings]

Figure 1 is a block diagram of an image coding device according to an embodiment 1 of the present invention.

Figure 2 is view for explaining the operation of an image coding device according to the embodiment 1 of the present invention.

Figure 3 shows an exemplified bit stream in an image coding device according to the embodiment 1 of the present invention.

Figure 4 is a block diagram of an image decoding device according to an embodiment 3 of the present invention.

Figure 5 is a block diagram of an image coding device according to an embodiment 5 of the present invention.

Figure 6 is view for explaining the operation of an image coding device according to the embodiment 5 of the present invention.

Figure 7 is a block diagram of an image coding device according to an embodiment 7 of the present invention.

Figure 8 is view for explaining the operation of an image coding device according to the embodiment 7 of the present invention.

Figure 9 is a block diagram of an image decoding device

according to an embodiment 8 of the present invention.

Figure 10 is a block diagram of an image decoding device according to an embodiment 9 of the present invention.

Figure 11 is a block diagram of an image coding device according to an embodiment 10 of the present invention, with a view for explaining the operation of the same device.

Figure 12 is a block diagram of an image decoding device according to an embodiment 11 of the present invention, with a view for explaining the operation of the same device.

Figure 13 is view for explaining the operation of an image coding device that is an embodiment 2 of the present invention.

Figure 14 is view for explaining the operation of an image coding device according to an embodiment 6 of the present invention.

Figure 15 is view for explaining the operation of an image decoding device according to the embodiment 4 of the present invention.

Figure 16 is a block diagram of a prior art, with a view for explaining the operation of the same device.

Figure 17 is a block diagram of a prior art.

Figure 18 is a block diagram of a prior art.

Figure 19 is a view for explaining a prior art.

Figure 20 is a block diagram of a prior art.

Figure 21 is a view for explaining a prior art.

[Explanations of Letters and Numerals]

101- Tile Decomposition Portion

102- Wavelet Transform Portion

103- Quantizing portion

104- Entropy Coding Portion

105- Wavelet Coding Portion

106- Management Information Generating Portion

107- Coded Data Integrating Portion

401- Management Information Separating Portion

402- Coded Data Extracting Portion

403- Entropy Decoding Portion

404- Inverse Quantizing Portion

405- Inverse Wavelet Transform Portion

406- Wavelet Decoding Portion

407- Tile Combining Portion

501- Tile Decomposition Portion

502- Adjacent Pixel Adding Portion

503- Wavelet Transform Portion

504- Quantizing portion

505- Entropy Coding Portion

506- Wavelet Coding Portion

507- Management Information Generating Portion

508- Coded Data Integrating Portion

701- Wavelet Transform Portion

702- Tile Composing Portion

703- Quantizing portion

704- Entropy Coding Portion

705- Wavelet Coding Portion

706- Management Information Generating Portion

707- Coded Data Integrating Portion

901- Management Information Separating Portion

902- Coded Data Extracting Portion

903- Entropy Decoding Portion

904- Inverse Quantizing Portion

905- Inverse Wavelet Transform Portion

906- Wavelet Decoding Portion

907- Tile Integrating Portion

1001- Management Information Separating Portion

1002- Coded Data Extracting Portion

1003- Entropy Decoding Portion

1004- Inverse Quantizing Portion

1005- Wavelet Coefficient Rearranging Portion

1006- Inverse Wavelet Transform Portion

1007- Wavelet Decoding Portion

1101- Wavelet Transform Portion

1102- Memory

1201- Memory

1202- Inverse Wavelet Transform Portion

1601, 1605, 1609, 1613- Tile Decomposition Portion

1604, 1608, 1612- 1/2 Contraction Portion

1602, 1606, 1610, 1614- JPEG Compressing Portion

1603, 1607, 1611, 1615- Coded Data Integrating Portion

1701- Wavelet Transform Portion

1702- Quantizing Portion

1703- Entropy Coding Portion

1704- Wavelet Coding Portion

1801, 1814, 1826- Horizontal Low-Pass Filter

1802, 1815, 1827- Horizontal High-Pass Filter

1803, 1805, 1816, 1818, 1828, 1830- Vertical Low-pass Filter

1804, 1806, 1817, 1819, 1829, 1831- Vertical High-pass Filter

1807 to 1812, 1820 to 1825, 1832 to 1837- 1/2 Sampling Portion

2013- Low-horizontal and Low-vertical Frequency Subband

2001- Entropy Decoding Portion

2002- Inverse Quantizing Portion

2003- Inverse Wavelet Transform Portion

2004- Wavelet Decoding Portion

2101- Pixel to which a Filter is Applied

2102- Area to be covered by a Filter

FIG.1

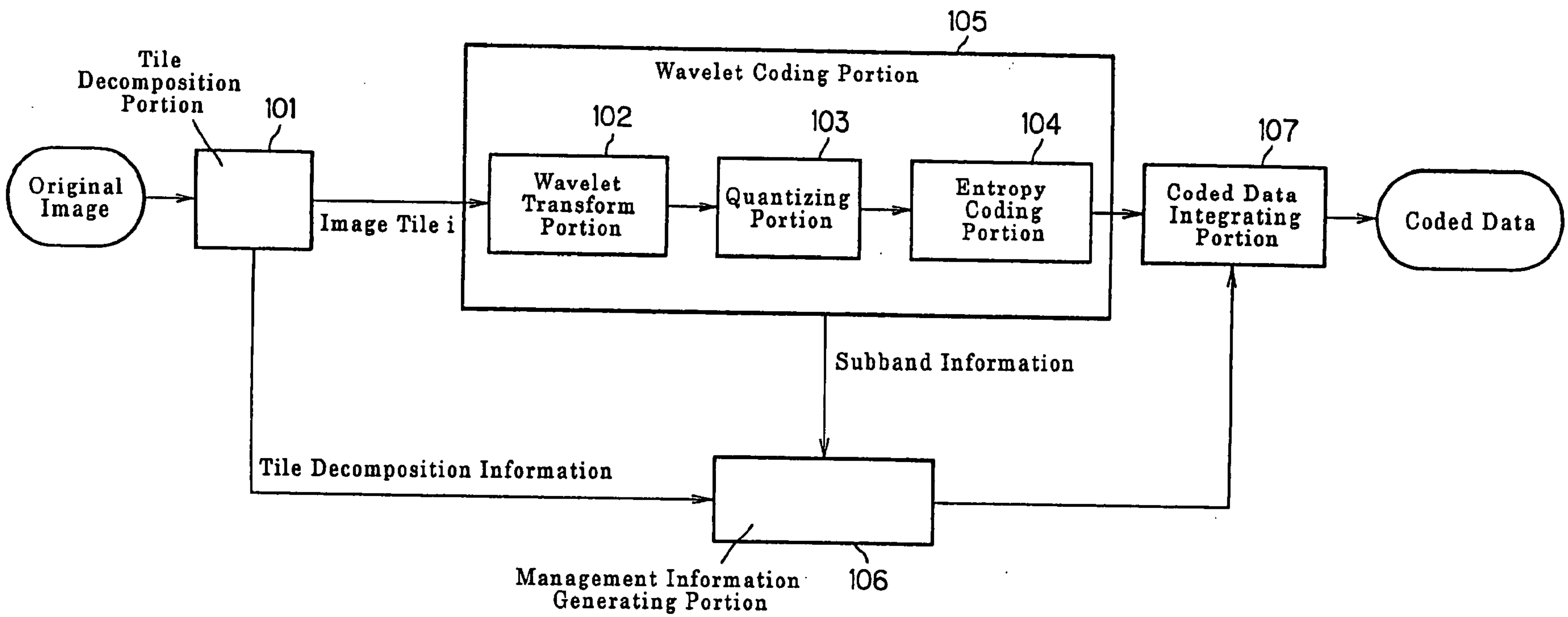

Original Image
Tile Decomposition Portion
101
Image Tile i
105
Wavelet Coding Portion
102
Wavelet Transform Portion
103
Quantizing Portion
104
Entropy Coding Portion
107
Coded Data Integrating Portion
Coded Data
Subband Information
Tile Decomposition Information
Management Information Generating Portion
106

FIG.2

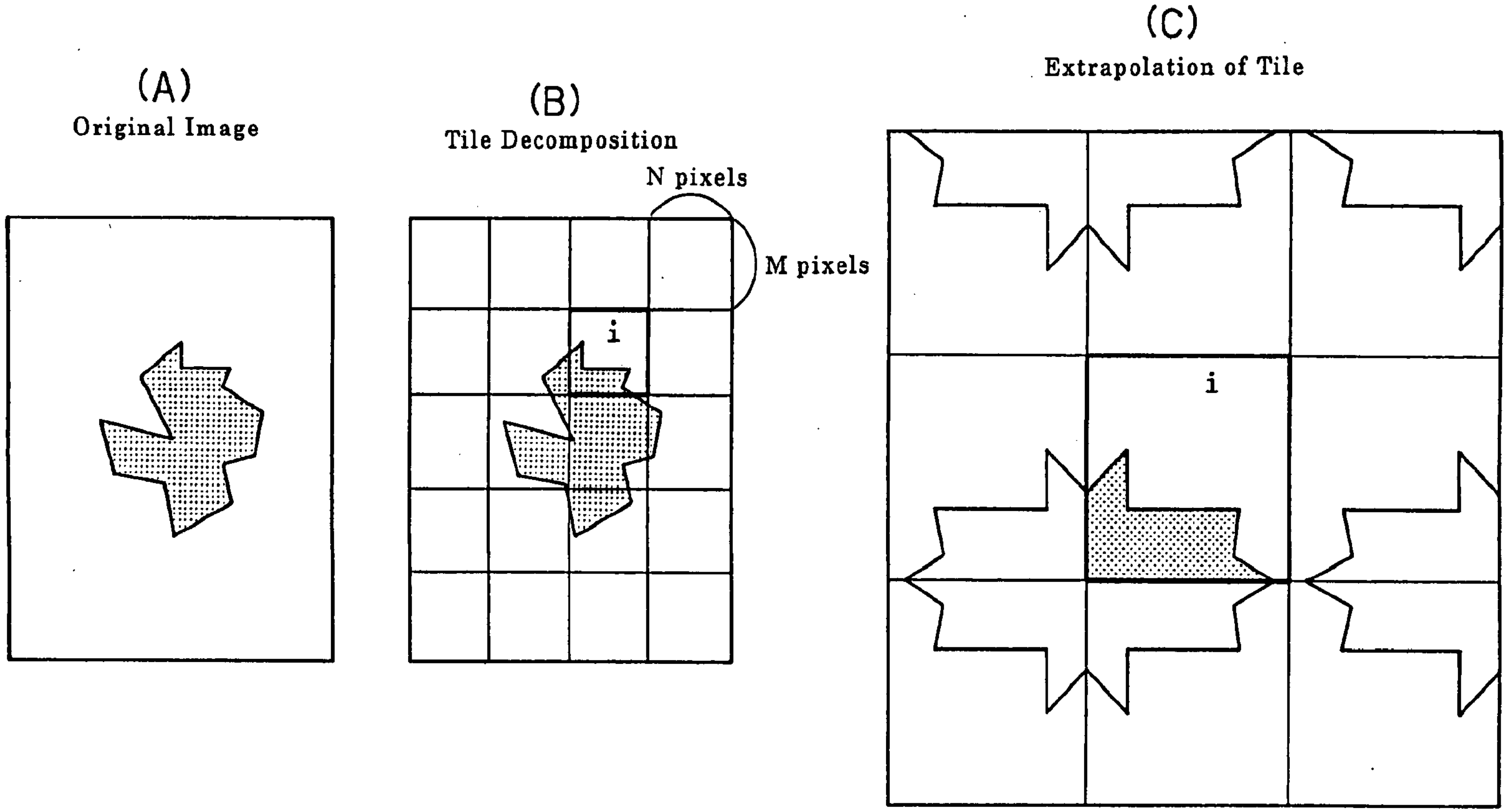

(A)
Original Image
(B)
Tile Decomposition
N pixels
M pixels
i
(C)
Extrapolation of Tile
i

FIG.3

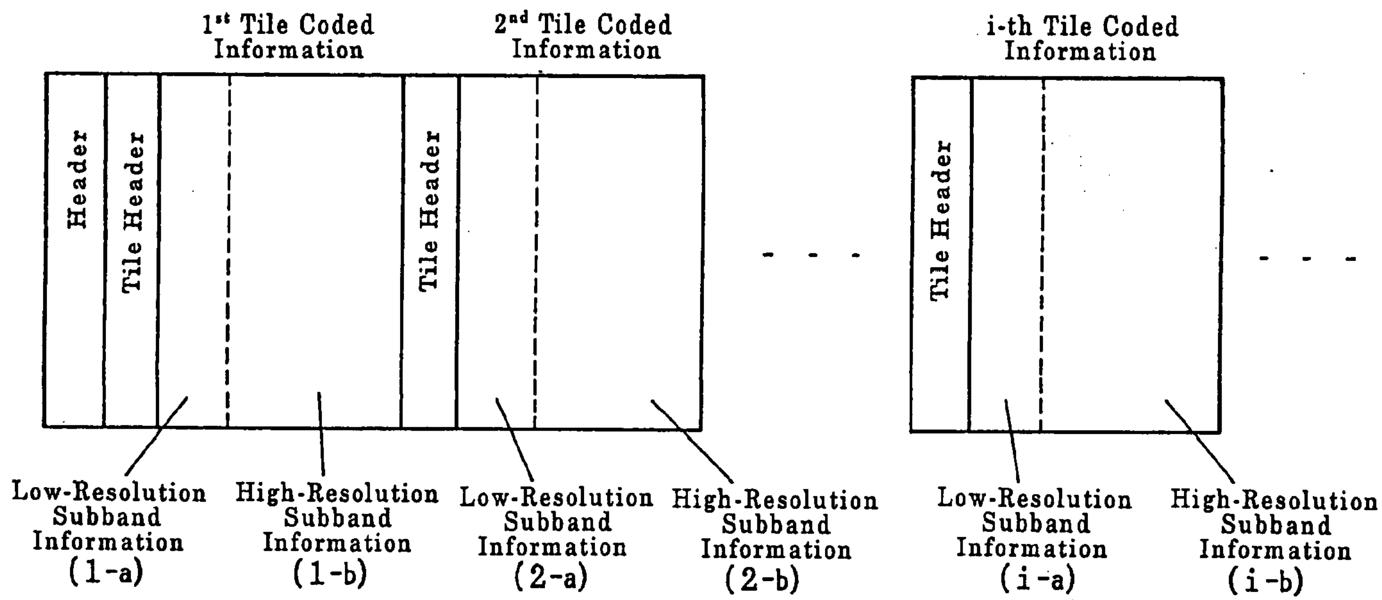
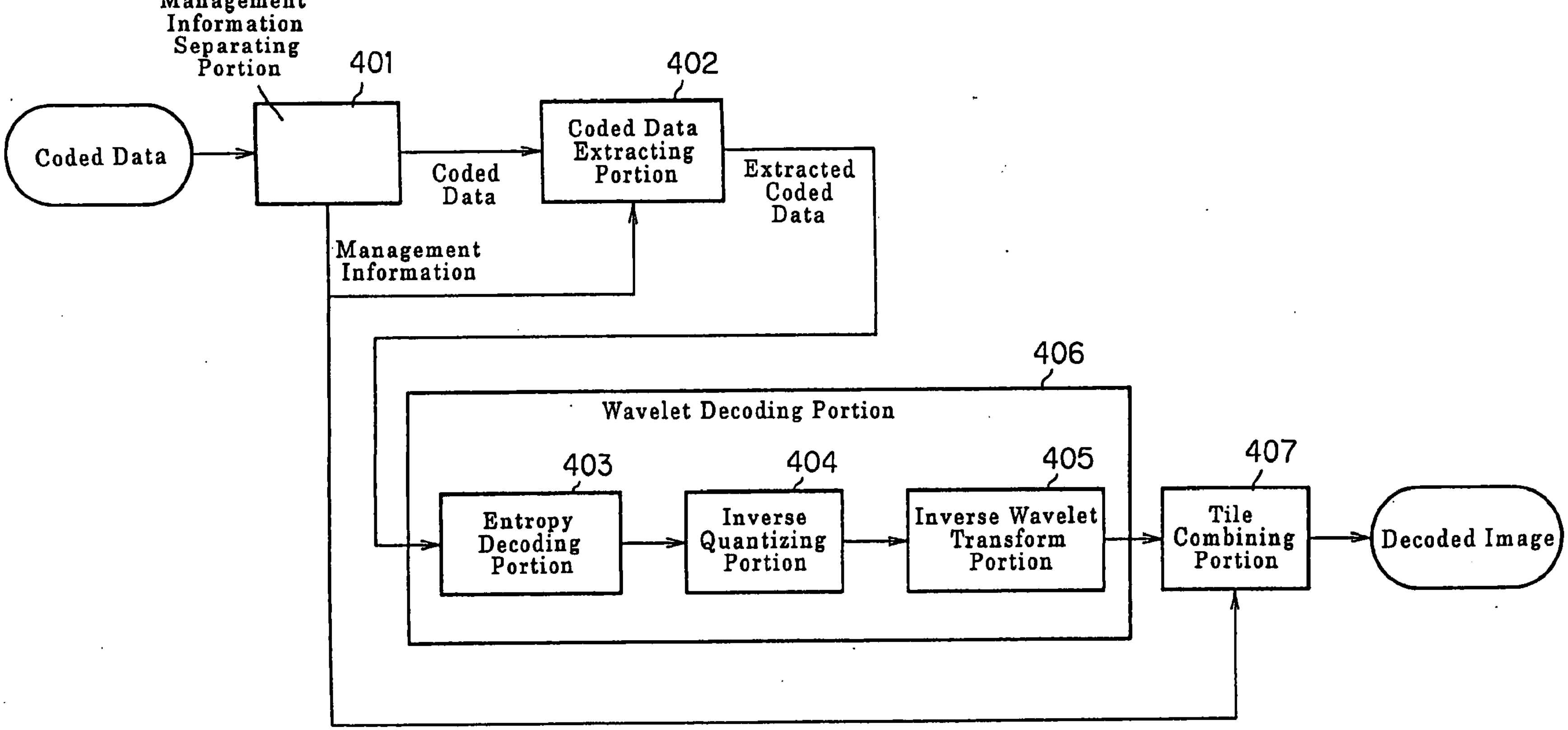
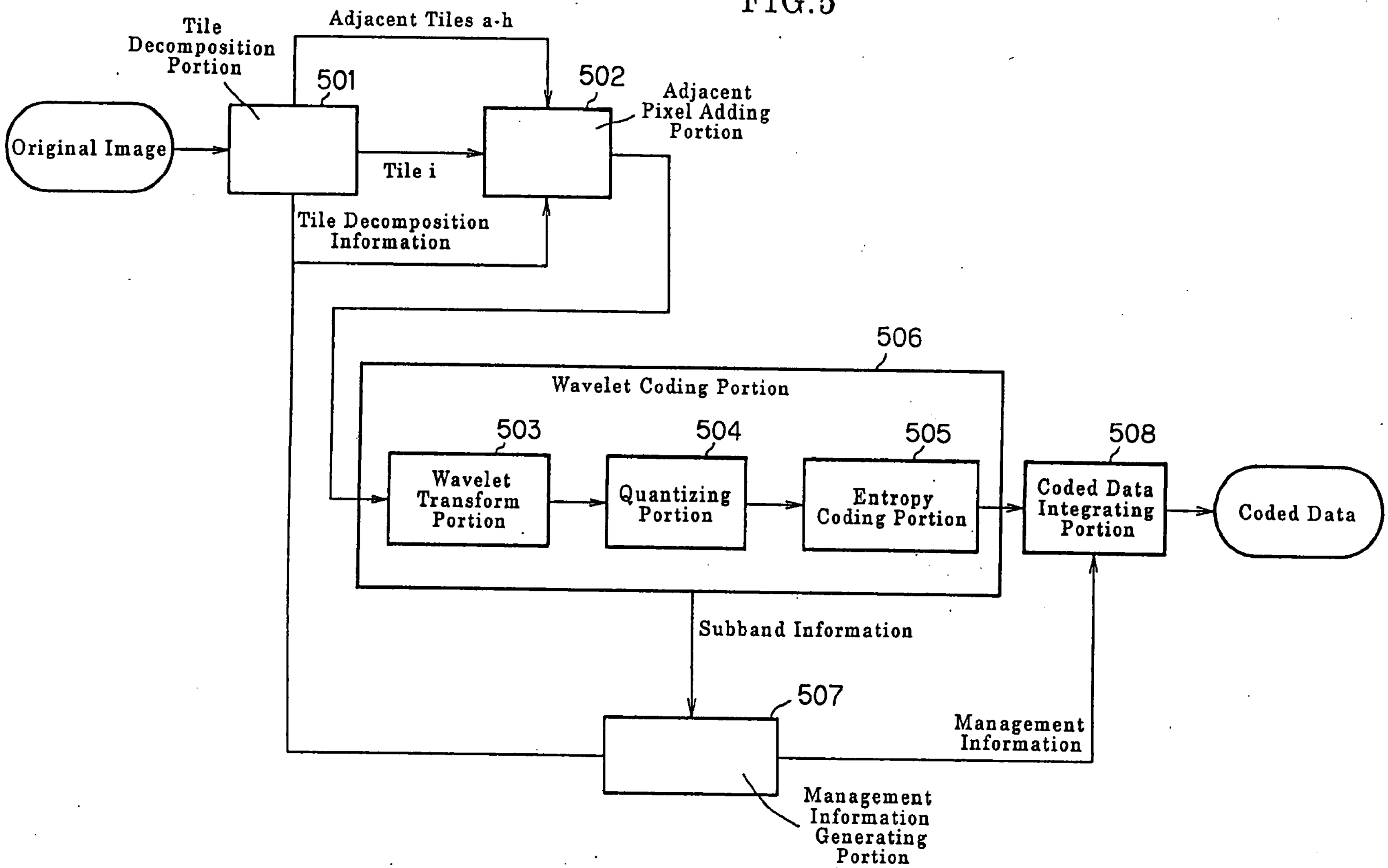

1st Tile Coded Information
2nd Tile Coded Information
i-th Tile Coded Information
Header
Tile Header
Tile Header
Tile Header
Low-Resolution Subband Information (1-a)
High-Resolution Subband Information (1-b)
Low-Resolution Subband Information (2-a)
High-Resolution Subband Information (2-b)
Low-Resolution Subband Information (i-a)
High-Resolution Subband Information (i-b)

FIG.4



Management Information Separating Portion
401
402
Coded Data
Coded Data
Coded Data Extracting Portion
Extracted Coded Data
Management Information
406
Wavelet Decoding Portion
403
404
405
407
Entropy Decoding Portion
Inverse Quantizing Portion
Inverse Wavelet Transform Portion
Tile Combining Portion
Decoded Image

FIG.5



Original Image
Tile Decomposition Portion
501
Adjacent Tiles a-h
Tile i
Tile Decomposition Information
502
Adjacent Pixel Adding Portion
506
Wavelet Coding Portion
503
Wavelet Transform Portion
504
Quantizing Portion
505
Entropy Coding Portion
508
Coded Data Integrating Portion
Coded Data
Subband Information
507
Management Information Generating Portion
Management Information

FIG.6

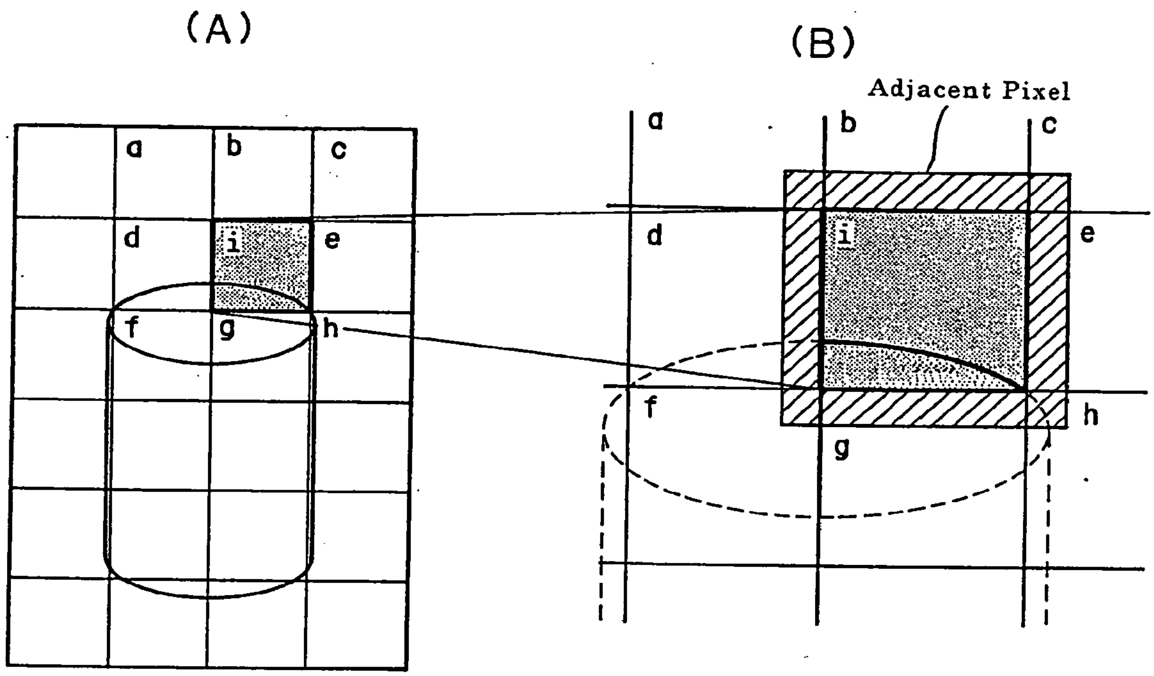


FIG.7

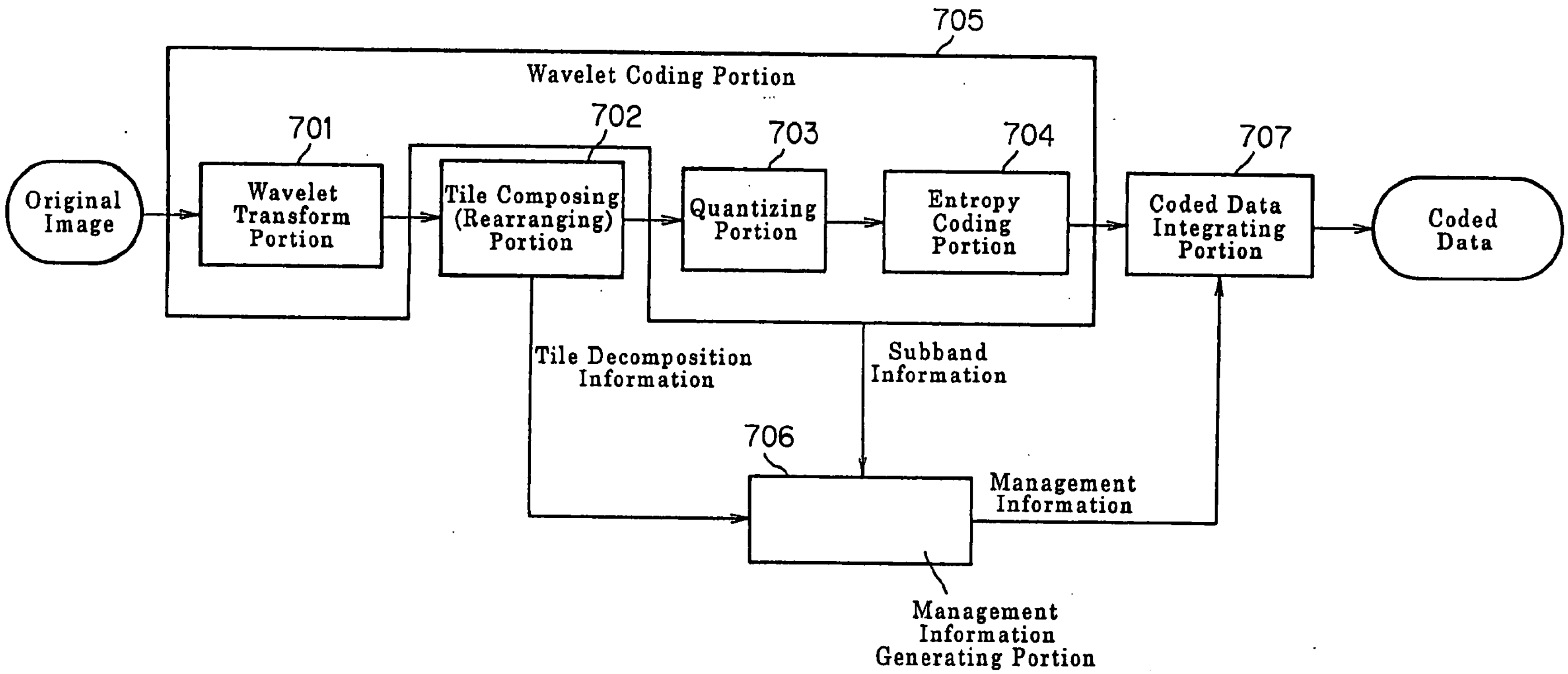
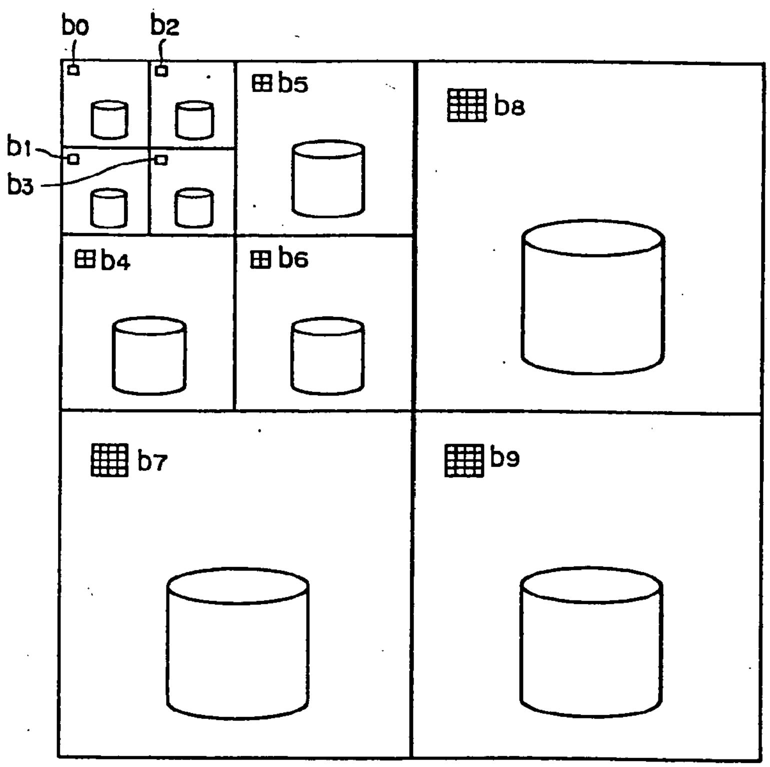

705
Wavelet Coding Portion
701
Original Image
Wavelet Transform Portion
702
Tile Composing (Rearranging) Portion
703
Quantizing Portion
704
Entropy Coding Portion
707
Coded Data Integrating Portion
Coded Data
Tile Decomposition Information
Subband Information
706
Management Information
Management Information Generating Portion

FIG.8

(A)



(B)

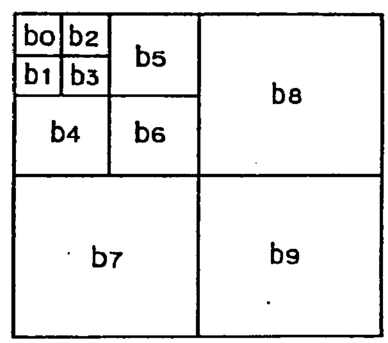


FIG.9

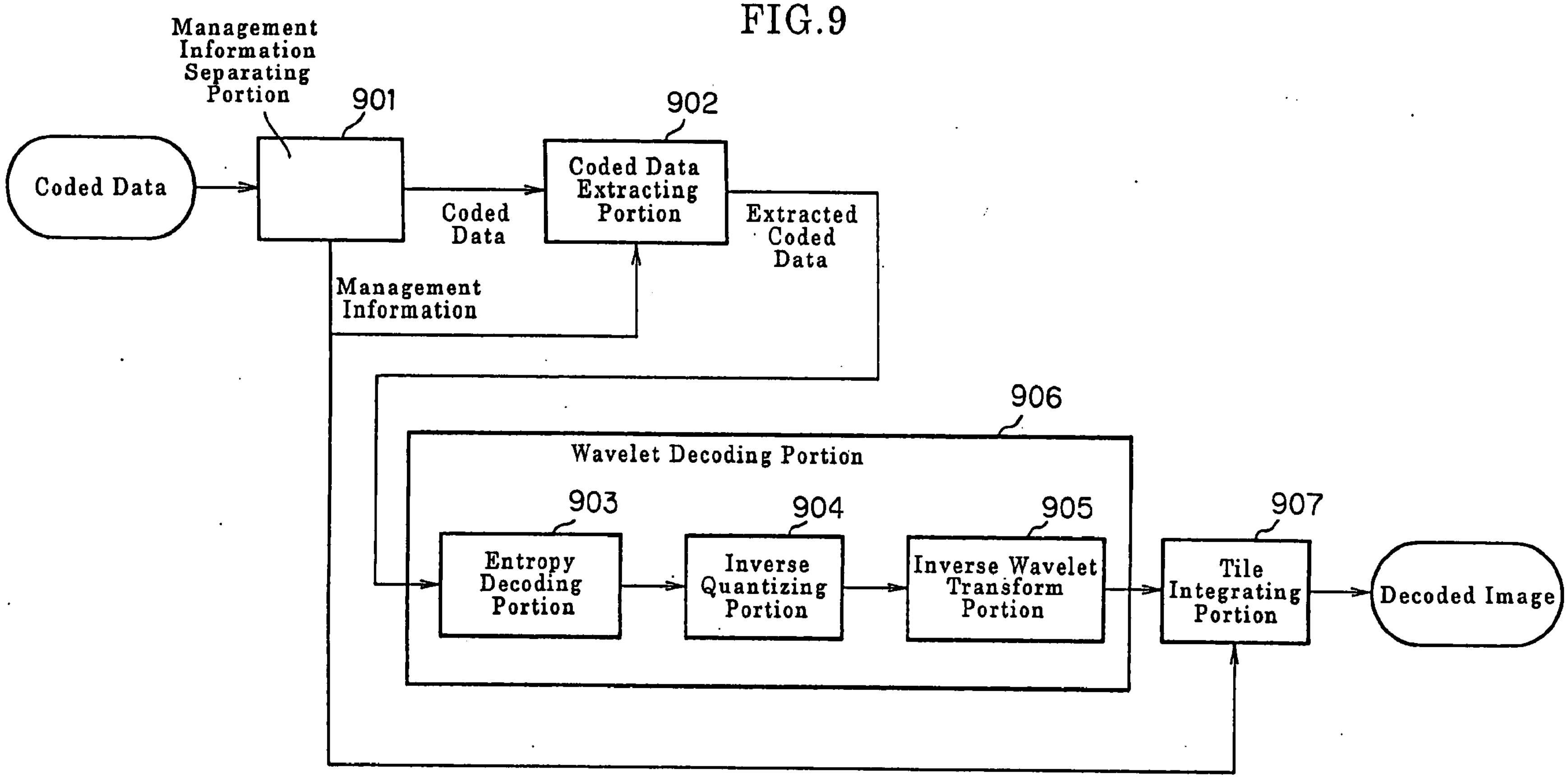

Coded Data
Management Information Separating Portion
901
Coded Data
902
Coded Data Extracting Portion
Extracted Coded Data
Management Information
906
Wavelet Decoding Portion
903
Entropy Decoding Portion
904
Inverse Quantizing Portion
905
Inverse Wavelet Transform Portion
907
Tile Integrating Portion
Decoded Image

FIG.10

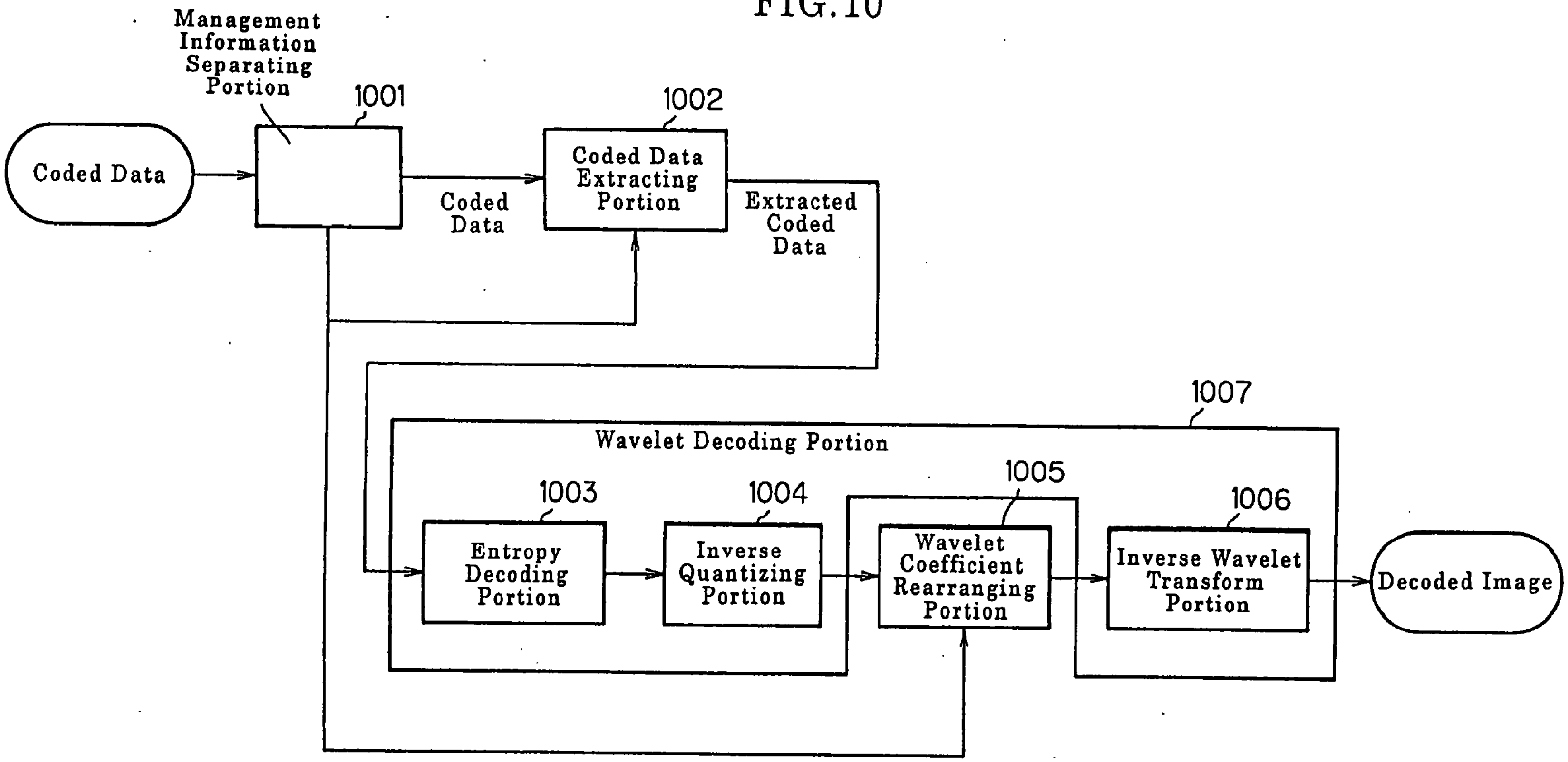
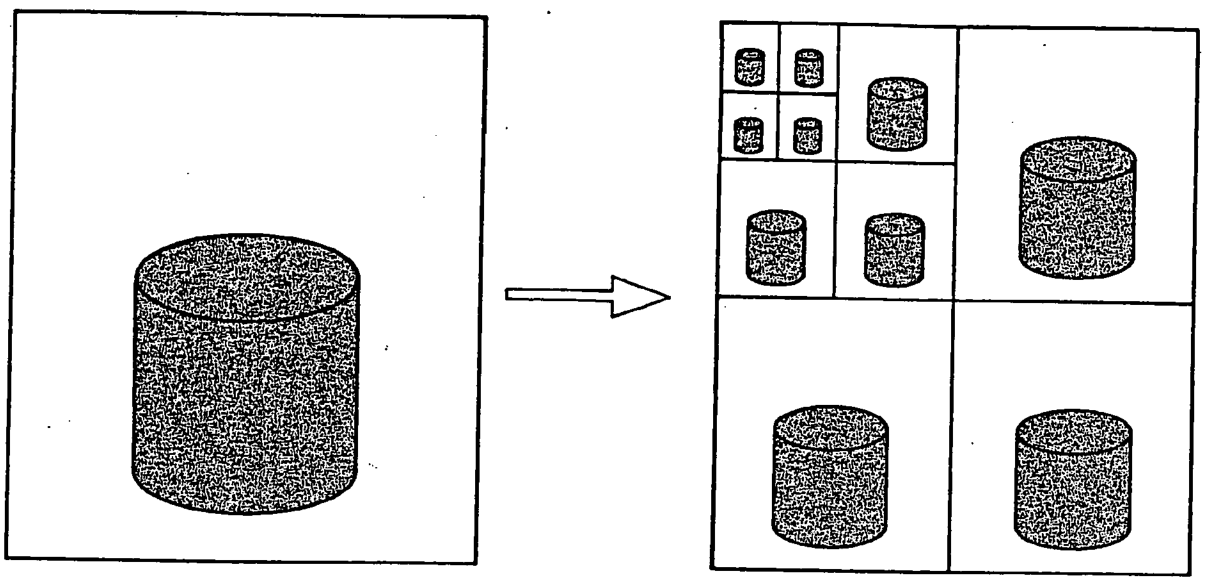

Management
Information
Separating
Portion
1001
Coded Data
Coded
Data
1002
Coded Data
Extracting
Portion
Extracted
Coded
Data
1007
Wavelet Decoding Portion
1003
Entropy
Decoding
Portion
1004
Inverse
Quantizing
Portion
1005
Wavelet
Coefficient
Rearranging
Portion
1006
Inverse Wavelet
Transform
Portion
Decoded Image

FIG.11

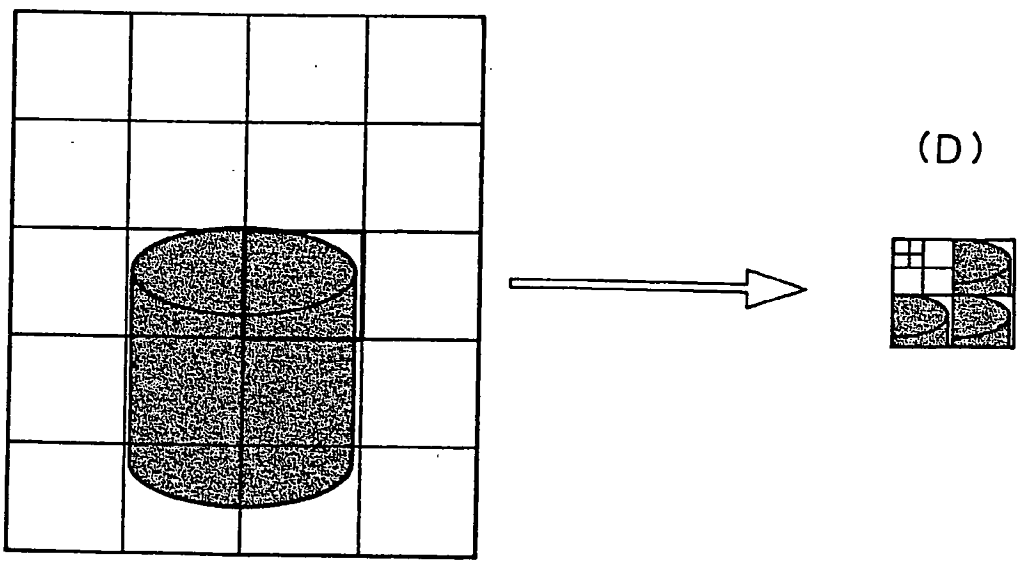
(A)

(B)



(C)

(D)



(E)

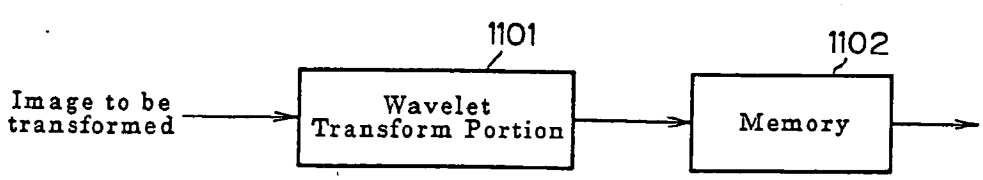

1101
1102
Image to be transformed
Wavelet Transform Portion
Memory

FIG.12

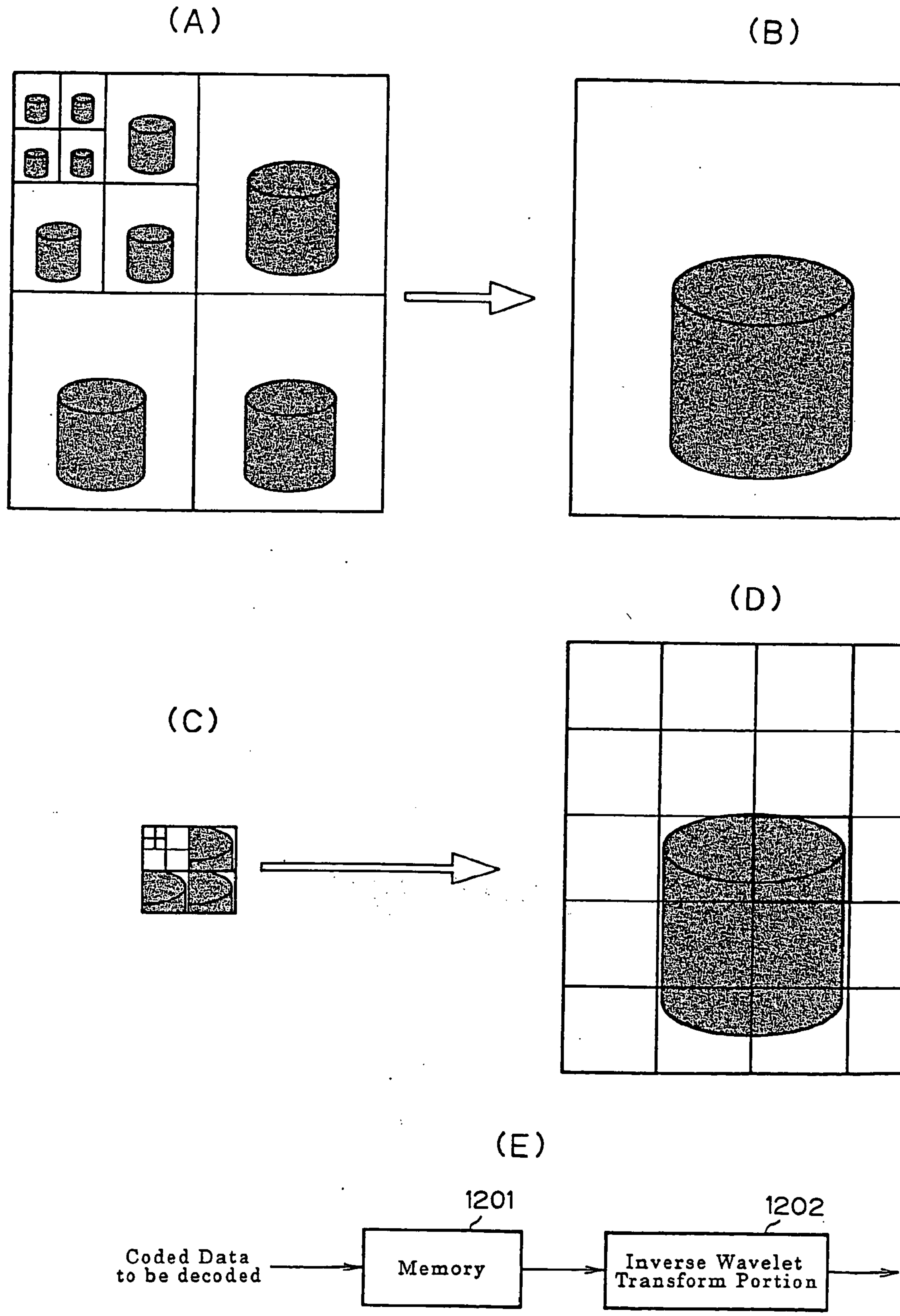

(A)
(B)
(C)
(D)
(E)
1201
1202
Coded Data
to be decoded
Memory
Inverse Wavelet
Transform Portion

FIG.13

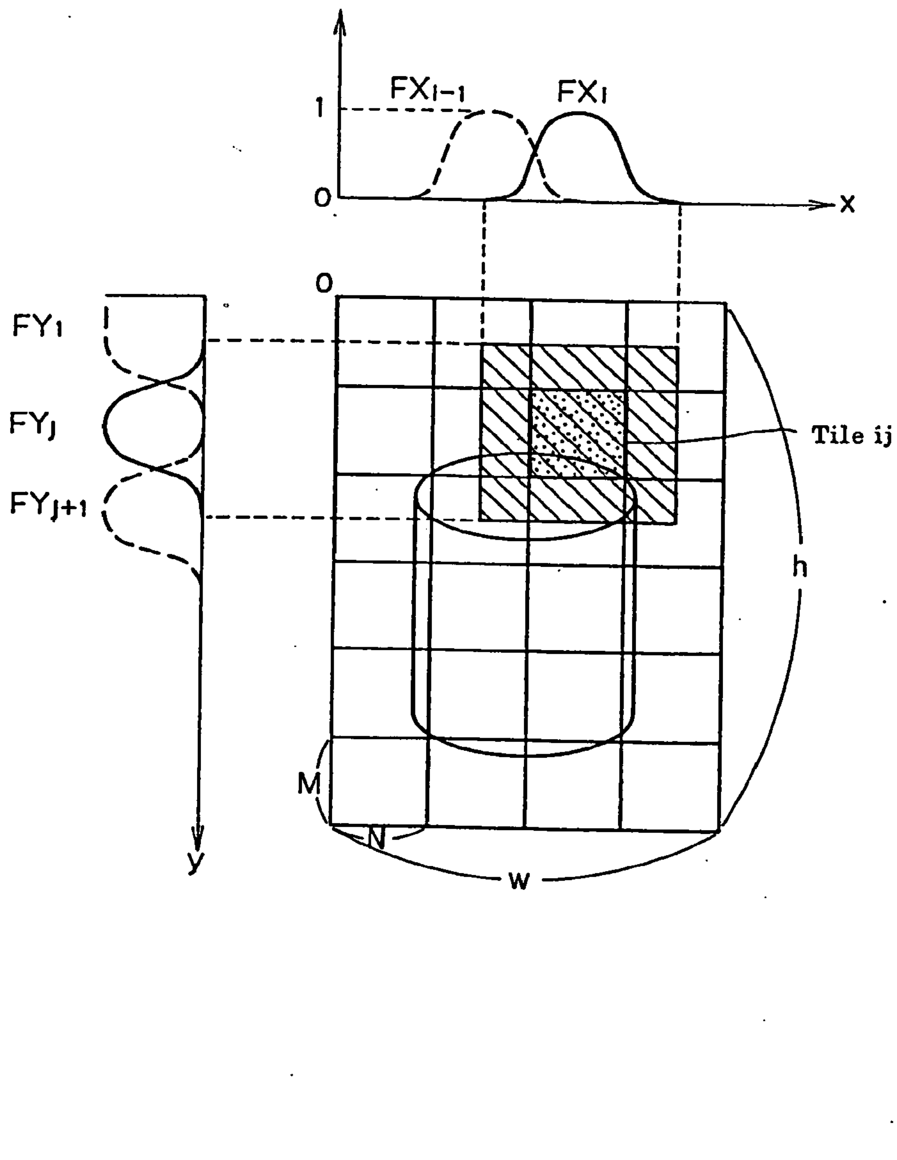
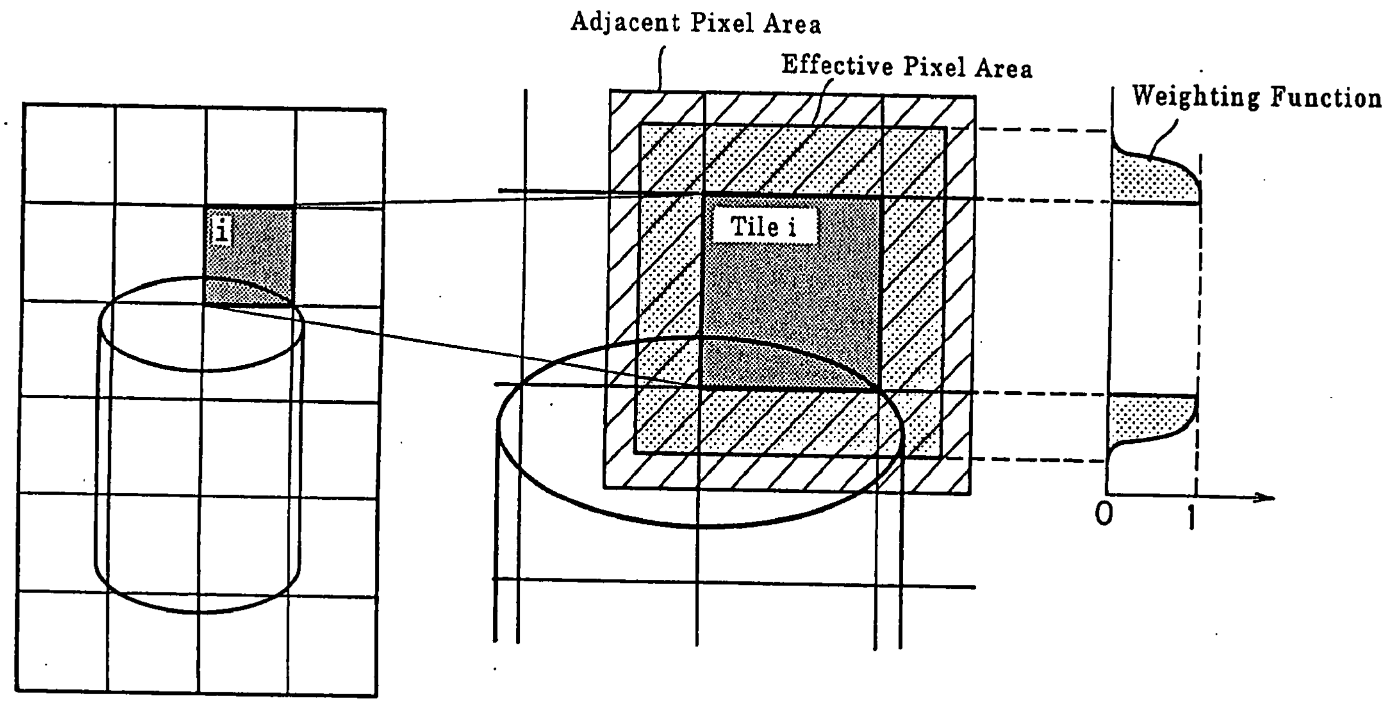


FIG.14



Adjacent Pixel Area
Effective Pixel Area
Weighting Function
Tile i
i
0
1

FIG.15

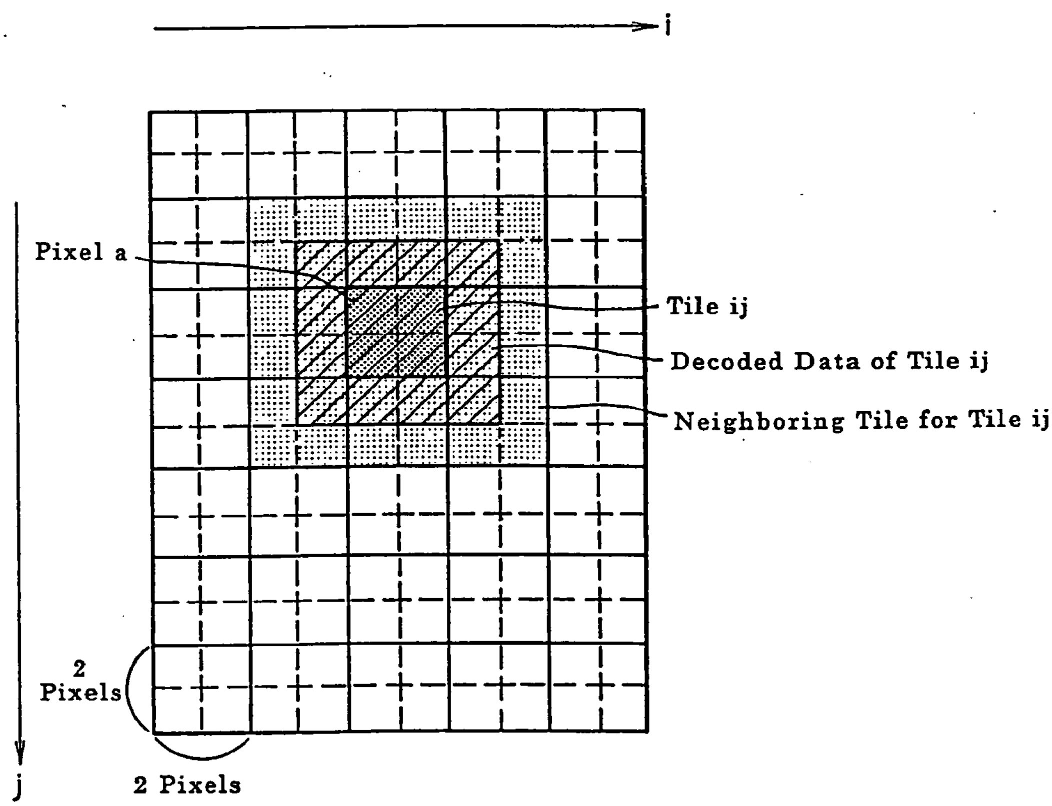

i
Pixel a
Tile ij
Decoded Data of Tile ij
Neighboring Tile for Tile ij
2
Pixels
j
2 Pixels

FIG.16
(A)

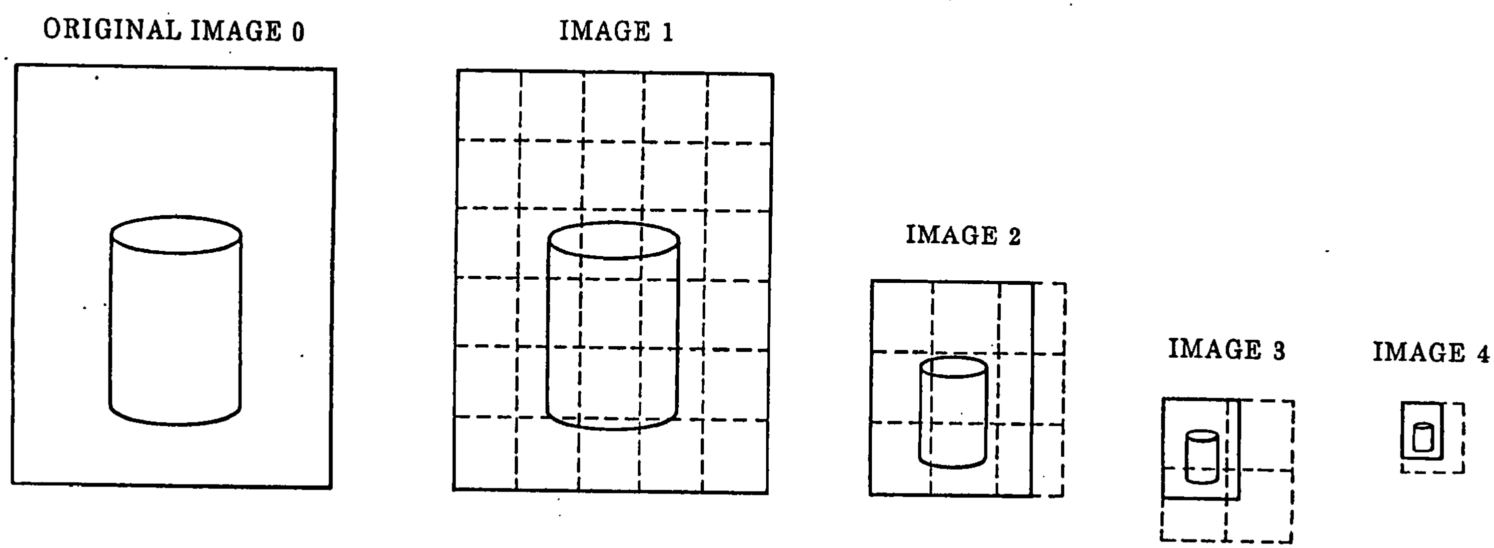


FIG.16
(B)

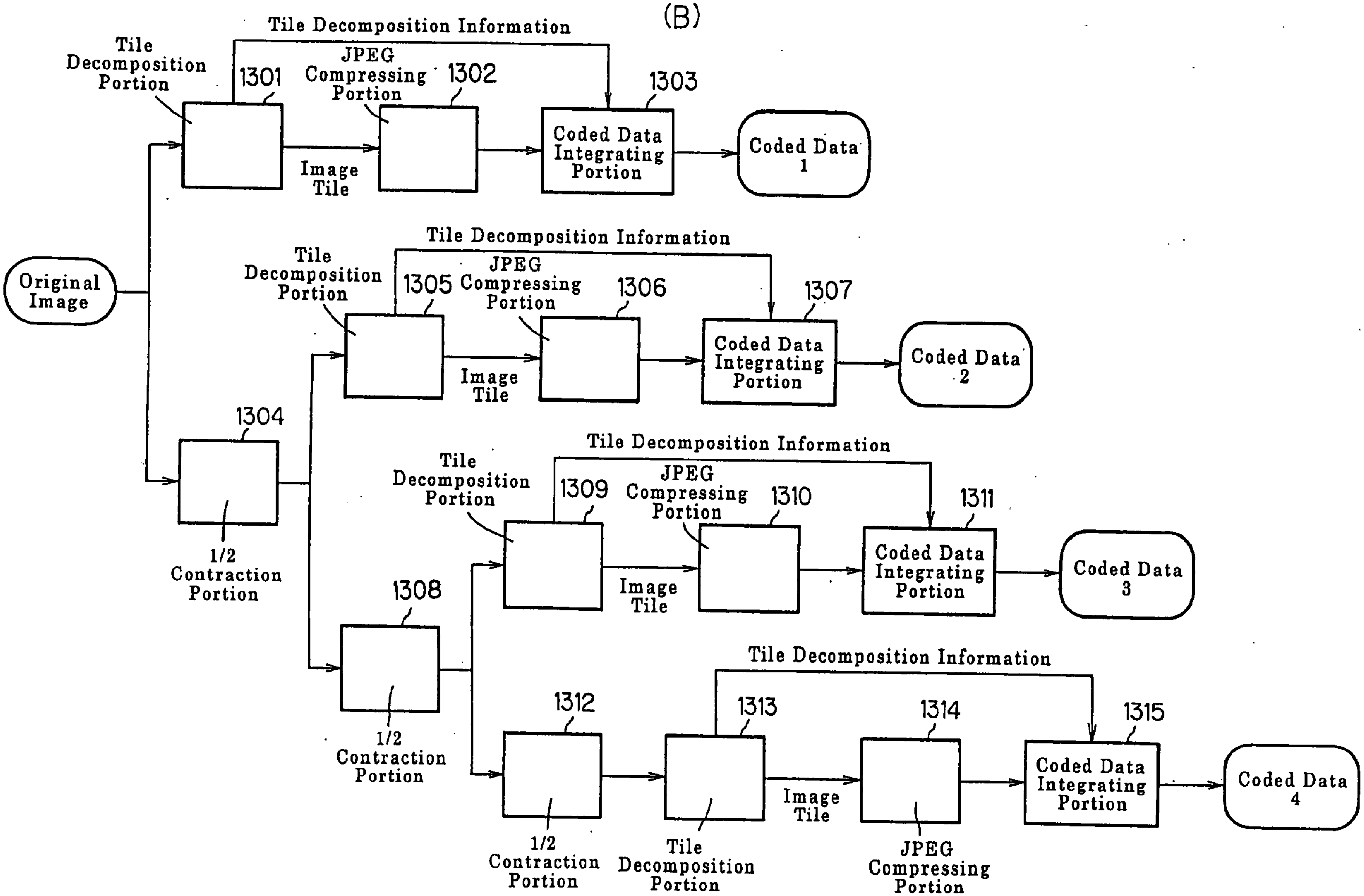

Original Image
Tile Decomposition Information
Tile Decomposition Portion
1301
JPEG Compressing Portion
1302
1303
Image Tile
Coded Data Integrating Portion
Coded Data 1
1304
1/2 Contraction Portion
Tile Decomposition Information
Tile Decomposition Portion
1305
JPEG Compressing Portion
1306
1307
Image Tile
Coded Data Integrating Portion
Coded Data 2
1308
1/2 Contraction Portion
Tile Decomposition Information
Tile Decomposition Portion
1309
JPEG Compressing Portion
1310
1311
Image Tile
Coded Data Integrating Portion
Coded Data 3
Tile Decomposition Information
1312
1313
1314
1315
1/2 Contraction Portion
Tile Decomposition Portion
Image Tile
JPEG Compressing Portion
Coded Data Integrating Portion
Coded Data 4

FIG.17

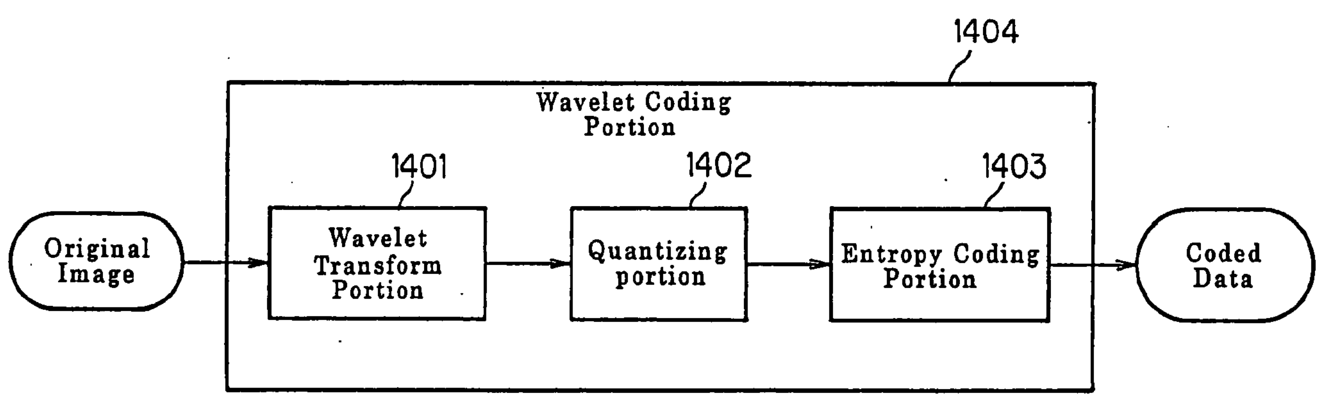

1404
Wavelet Coding Portion
1401
1402
1403
Original Image
Wavelet Transform Portion
Quantizing portion
Entropy Coding Portion
Coded Data

FIG.18

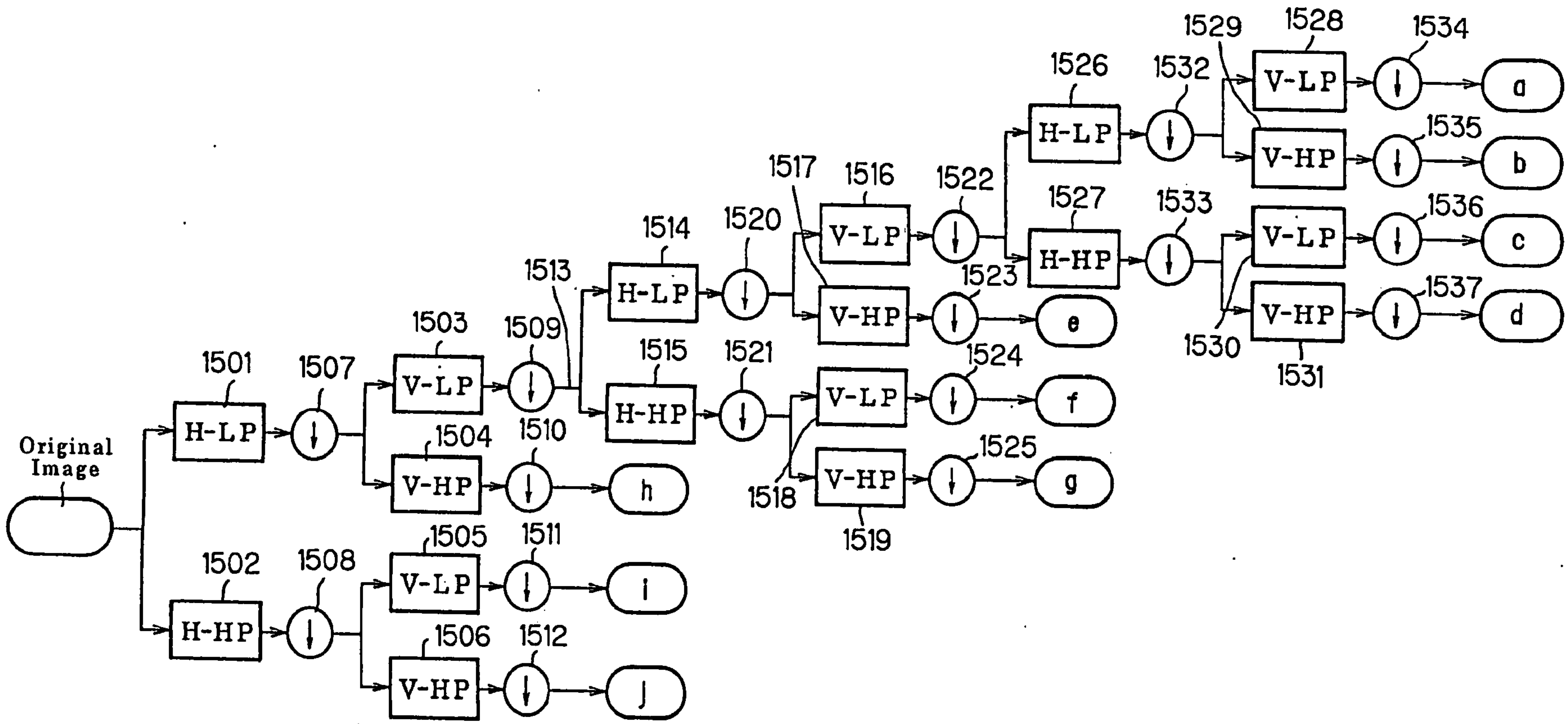

Original Image
H-LP
H-HP
V-LP
V-HP
H-LP
H-HP
V-LP
V-HP
V-LP
V-HP
H-LP
H-HP
V-LP
V-HP
V-LP
V-HP
V-LP
V-HP
V-LP
V-HP
a
b
c
d
e
f
g
h
i
j
1501
1502
1503
1504
1505
1506
1507
1508
1509
1510
1511
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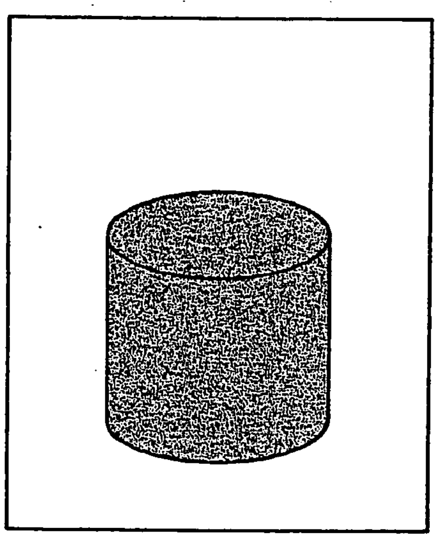
FIG.19

(A)

Original Image



(B)

Wavelet Transform Data

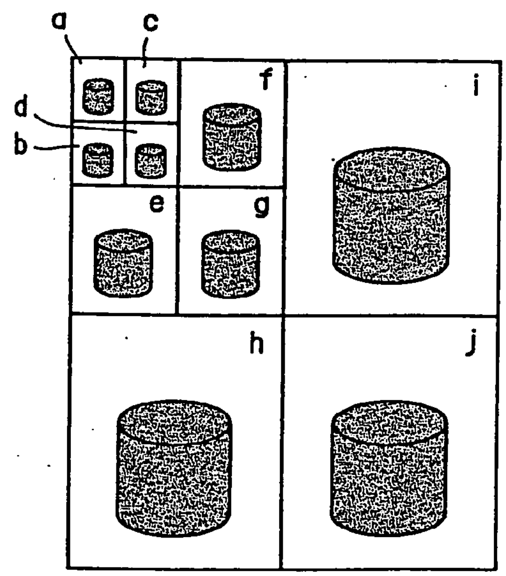


FIG.20

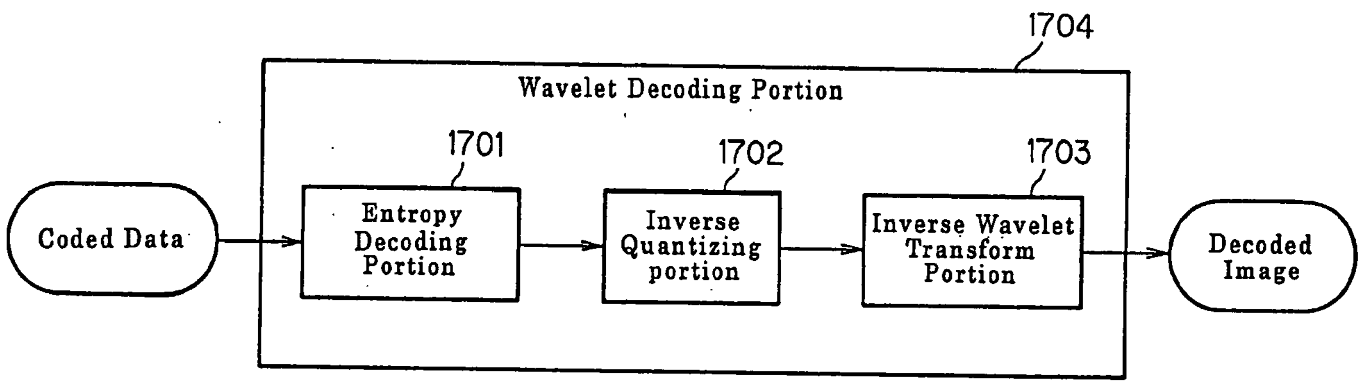
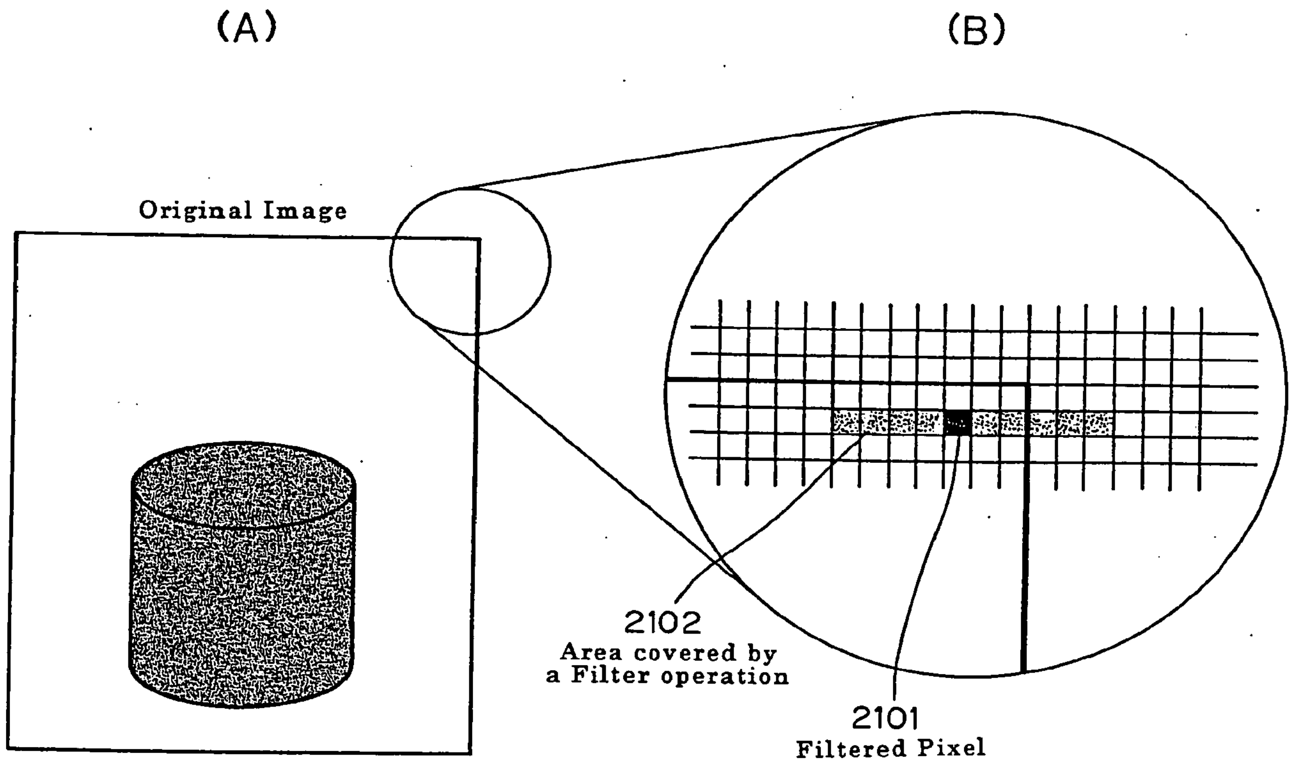

1704
Wavelet Decoding Portion
1701
1702
1703
Coded Data
Entropy Decoding Portion
Inverse Quantizing portion
Inverse Wavelet Transform Portion
Decoded Image

FIG.21


(A)
(B)
Original Image
2102
Area covered by
a Filter operation
2101
Filtered Pixel

[Document Name] Abstract

[Abstract]

[Object]

An image encoder/decoder by which a partial image is encoded easily with a resolution meeting the user's demand, the encoded amount of data is not increased and a necessary capacity of memory can be reduced.

[Solving Means]

The image encoder has a tile decomposition portion which divides image data into tiles of N pixels x M pixels, a wavelet transform coding portion which extrapolates predetermined data at the peripheries of the tiles outputted from the tile decomposition portion and performs subdivision to perform wavelet encoding, a management information generating portion which generates information for managing the encoded data in order that the encoded data outputted from the wavelet transform coding portion can be decoded for each tile and for each subband of the wavelet encoding, and an coded data integration portion which links the encoded data encoded by wavelet encoding for each tile by using the output of the management information generating portion and adds the managing information to the encoded data.

[Selected Drawing] Fig. 1